PLATE XXII

N

W E W

ζ Orionis and the Nebulae on the East and North

Scale: 1 mm = 12″.8 (0.81 that of original negative)
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BRIGHT AND DARK NEBULAE NEAR ζ ORIONIS PHOTOGRAPHED WITH THE 100-INCH HOOKER TELESCOPE[1]

By JOHN C. DUNCAN.

The region surrounding the star ζ, at the southeastern end of the Belt of Orion, has been studied on account of its remarkable nebulae by several observers, the first of whom was W. Herschel, who listed it as No. 25 of his fifty-two regions that contain diffuse nebulosity.[2] Six of his nebulae are included by Dreyer in the *New General Catalogue* or the first *Index Catalogue*. Photographs showing many of its interesting features have been published and discussed by W. H. Pickering,[3] Roberts,[4] Wolf,[5] Keeler,[6] Barnard,[7] and Curtis.[8]

During the past winter I have made photographs of this region at the principal focus of the 100-inch Hooker telescope, and the great focal length, light-gathering power, and resolving power of this instrument have brought out certain remarkable features with great distinctness. Two of these photographs are reproduced in Plates XXI and XXII. The original negatives are 8 x 10 inches in size, but in making the reproductions only the central parts were used and these were reduced in scale. The excellence of the reproductions is due largely to the skill of Mr. Ellerman, who increased the intensity of the images of faint nebulosities by successive copying on slow plates.

Plate XXI.—Center of plate (1920.0), $\alpha = 5^h\ 37^m.0$, $\delta = -2^\circ\ 31'$. 1920, November 13. Exposure three hours. Seeing good, but figure of mirror somewhat imperfect. Seed 23 plate.

The bright star ζ Orionis is just off the north side of the plate, and a bright ray, produced by diffraction of its light by one of the steel

[1]Reprinted from the *Astrophysical Journal*, June, 1921.

[2]*Philosophical Transactions*, **101**, 276, 1811.

[3]*Annals of Harvard College Observatory*, **32**, 66, and Plate III, Fig. 3, 1895.

[4]*Astrophysical Journal*, **17**, 74, and Plate IV, 1903; also, *Monthly Notices*, **63**, 31, and Plate I, 1903.

[5]*Monthly Notices*, **63**, 304, and Plate II, 1903.

[6]*Publications of the Lick Observatory*, **8**, Plate XIII, 1908.

[7]*Astrophysical Journal*, **38**, 500, and Plate XX, Fig. 1, 1913; also *Publications of the Lick Observatory*, **11**, Plate XX, 1913.

[8]*Publications of the Astronomical Society of the Pacific*, **30**, 66, and Plate IV, Fig. 1, 1918; *Publications of the Lick Observatory*, **13**, 23, and Plate II, Fig. 5, 1918.

supports of the secondary mirror, extends from it toward the south and east. The brightest star shown is D. M. —2°1337, 19 mm. from the bottom of the plate and 42 mm. from the right side. Its visual magnitude, as given by the *Durchmusterung*, is 7.5.

Almost vertically through the middle of the plate lies the nebula I.C. 434, which was discovered photographically at the Harvard Observatory in 1887.[1] It here appears as the bright fringe of a diffuse nebulosity that fills the western half of the field. This diffuse nebulosity is remarkably striated, the striae lying in a direction approximately east and west. The fringe has numerous branches and irregularities and is suggestive of the edge of a relatively thin sheet that is crumpled and turned edgewise to the observer. Earlier observers have noted the scarcity of faint stars east of the nebulous fringe as contrasted with their great abundance on the west. The effectiveness of the Hooker telescope in photographing faint stars makes this contrast very conspicuous.

In the northeastern corner of the field is the nebula N. G. C. 2023, which surrounds a star of magnitude 8.5, not shown on the plate because of overexposure of the nebula. It is terminated rather abruptly on the west side, and shows a clearly defined dark marking on the east. The existence of spiral rays, noted by the Harvard observers,[2] is not here confirmed.

By far the most interesting object shown on the plate is the dark cloud near the center, which forms a bay in the bright nebula and which has attracted attention since the earliest photographic observations of the region. It is listed by Barnard as No. 33 of his dark markings of the sky.[3] On the present plate, faint lights appear within the cloud, and a notable silver lining is shown along its western edge. On the original negative the eastern boundary can be traced on the faint background of the sky, and is seen to extend north and east nearly to N. G. C. 2023. An aid to tracing its position is found in the diffracted ray from ζ Orionis, which seems to have been too faint to affect the plate perceptibly by its own light but is plainly visible where the plate has been brought to its threshold by the nebulous background, so that the ray is interrupted where it crosses the dark cloud. A second and much smaller and paler dark bay lies about 15′ north of Barnard 33, near the 8.5 magnitude star D. M. —2°1343, and a third about 6′ still farther north.

Plate XXII.—Center of plate (1920.0), $\alpha = 5^h\,37^m.3$, $\delta = -1°\,53'$. 1920, December 8. Exposure, 5 hours, 35 minutes. Sky somewhat hazy. Seed 30 plate.

ζ Orionis is near the west side of the plate, where irradiation has spread its light into a great blot. The star may be located accurately at the intersection of the rays produced by the mirror supports. At the

[1] *Annals of Harvard College Observatory*, **18**, 115, 1890.
[2] *Ibid.*, **18**, 116, 1890.
[3] *Astrophysical Journal*, **49**, 14, 1919.

extreme northwest corner of the plate is the nebula I. C. 431, and 10′ east of this is I. C. 432. These nebulae surround the stars D. M. —1°1001 and —1°1005 respectively, stars of about 8.5 visual magnitude. A few of the stars that lie near the north edge of Plate XXI appear also near the south edge of Plate XXII. The continuation of the nebula I. C. 434 toward ζ may be seen on Plate XXII, which shows also that the disparity in the number of faint stars on the east and west sides of the nebulous fringe continues some distance north of ζ, where the line of division seems to turn somewhat toward the west.

The greater part of Plate XXII is occupied by the remarkable nebula N. G. C. 2024, discovered in 1786 by W. Herschel, who described it[1] as a "remarkable nebulosity, divided in 3 or 4 large patches including a dark space." The brightest parts cover a space some 25′ in diameter, and there are faint extensions, one of which reaches as far as I. C. 432 on the northwest. Both this nebulosity and that of I. C. 434 can be traced on the original plate to within 5′ of ζ Orionis, where they are concealed in the glare about the bright star. The irregularities of the bright and dark markings of N. G. C. 2024 are such as to defy description, which fortunately is unnecessary, as they are well shown in the illustrations. The character of this nebulosity appears to be different from either that of I. C. 434 or that of the neighboring nebulous stars.

A study of the photographs of this region tends to the conviction that we have here to do with extended masses of not less than four distinct types: (1) the ropy, branching nebulosity of I. C. 434; (2) the nebulosity of N. G. C. 2024; (3) the nebulous stars N. G. C. 2023 and I. C. 431, 432, and 435;[2] (4) dark nebulosities, best exemplified by the cloud Barnard 33.

The phenomena shown suggest the following speculations: Perhaps the fringe of I. C. 434 represents the common boundary of a dense, dark mass on the east and a body of thin, luminous nebulosity on the west. These two masses may have a relative motion toward each other, which results in a concentration of the bright nebulosity along the line of contact, this concentrated nebulosity being the fringe. The faint nebulosity west of the fringe must be sufficiently transparent to transmit the light of the starry background, while the dark material on the east obscures all the stars behind it. The bright nebula N. G. C. 2024 seems to be of the nature of a bright outcropping of the dark nebula, which indeed is probably nowhere absolutely non-luminous unless it be so in the darkest part of Barnard 33. Perhaps the four stars that show nebulous burs—D. M. —1°1001, —1°1005, —2°1345, and —2°1350—are embedded in the dark nebula and illuminate that part of it which lies immediately around them, the nebulosities of the third type being due in part to this cause and in part to the same cause

[1] *Philosophical Transactions*, **79**, 248, 1789.

[2] The nebula I.C. 435 is some 20′ east of N.G.C. 2023 and is not shown in the illustrations. It surrounds the 8.5 magnitude star D.M. —2°1350.

as those of the second type. We may suppose the non-nebulous stars that appear east of I. C. 434 to lie between the observer and the dark nebula.

Mr. E. P. Hubble has kindly loaned me a plate made by him with the Hooker telescope 1920, November 18, which shows the region immediately north of ζ Orionis. The line of cleavage between the regions of few and of many stars is clearly marked on this plate, and passes in a zigzag fashion northwest of ζ nearly to I. C. 431, where it bends toward the west and returns, forming a bay about 15′ deep, and then passes northeastward to a point near the sixth-magnitude star —1°1004, about 1° north of ζ and near the north edge of the plate. There is on this plate no hint of a nebulosity similar to I. C. 434, and the line of cleavage has not here the regularity that is noticeable in that part of it lying south of ζ. Long-exposure photographs of the Orion region made with the 10-inch Cooke refractor of this observatory by Mr. Hubble and Mr. Pettit indicate that the obscuring mass east of ζ Orionis is only a part of a much larger region that extends several degrees toward the northeast, enveloping the bright nebula Messier 78, and also, though less plainly, some distance toward the south. The general outlines of this dark region can be traced on the Franklin-Adams chart.

Mount Wilson Observatory,
March 1921.

THE DAILY INFLUENCE OF ASTRONOMY.*

By W. W. CAMPBELL,
Director of the Lick Observatory, University of California.

In the great struggle through which the principal nations have passed, men and women at home labored intensively to maintain their ideals; countless millions of men fought valiently and many millions died for the ideals of their nations. Quick results, short cuts to the end in view, the achieving of victory regardless of cost, were the order of the day. Suddenly the problems of war gave way to the problems of peace. The intensive methods of war carried over to an unfortunate degree into the days of peace. Human energy, mobilized in behalf of the nations, applied unselfishly for the good of every person in the nation, for the well-being of all the nations, was diverted in regrettable measure to promoting selfish interests. The moral exultation of the war period was replaced in too many cases by the selfishness of individuals and organizations; by profiteering—a new word, coined to describe wide-spread conditions. The struggle in Russia, as the ex-

*From an address delivered at the dedication of the Warner and Swasey Observatory of the Case School of Applied Science.

treme case, is direct action for the sudden attainment of certain results, without due consideration for the rights of others. In all countries there are those who, seeing conditions not to their liking, in commerce, in education, in religion, in many phases of daily life, would cut and slash their way through the good, in order to uproot what, in their sight, is bad. This spirit exists in America, and throughout the world, in various degrees. Disturbances in the body politic may ensue for years, or a generation, by virtue of these attempted short cuts to results, but radical transformations in the social structure of a great modern nation, to endure, must find the people ready for them. The influences which prepare the way for desirable and enduring reforms are not those applied suddenly, but such as operate day and night, continuously, through long periods of time. The revolutions in Russia, in Mexico, in many parts of Latin America, attract our attention, but the really serious misfortunes of those lands lie much deeper, in their bad social, educational, economic conditions, which are operating unfavorably upon their civilization, every day of the year.

We may well inquire what it is that bears a nation onward and upward to greater things. It is unquestionably the spirit of idealism radiating from its various activities. It is the idealism in commercial life; that part of every man's affairs which is conducted with full respect for the rights of others; that part of every man's business which would not, through its publication, injure his good name. It is the idealism of the transportation system, which interchanges commodities to mutual advantage, and acquaints one section of the world with the good things of other sections. It is idealism in banking, in farming, in the honest days' labor at an honest wage. It is idealism in intellectual life; reverence for the truth, a desire to know the truth, and to live in harmony with the truth in one's surroundings.

A pessimist would today, as always, receive a short shrift, yet I venture to say the world was perhaps never more urgently in need of the biblical advice, "Prove all things; hold fast that which is good." This expression of great wisdom has never been surpassed as a statement of the principles which govern men of science in their search for the truth.

The chief value of scientific method and acurate knowledge lies not in their worship by the intellectual few, not in their applications to industry, but in their influence upon the daily life of the people. The remarkable advance in civilization within the leading nations in recent centuries has been due to the daily and hourly influence of the scientific spirit, more than to any other element. Those nations which possess it are forging ahead by leaps and bounds, and those which do not are dropping out of the race. The unscientific nations are threatened with absorption by their more scientific neighbors, not so much because they do not invent or perfect the most powerful cannon, the sturdiest dreadnaught, the speediest airplane, or the subtlest submarine, but because the scientific nations are forging ahead of them in arts of peace,

in the modes of thought in the affairs of daily life. The unscientific nations are without serious influence in the world, not because they are unwarlike—the Turks and essentially all Mohammedans are warlike enough to suit everybody—but because they are lacking in the vision and the efficiency which accompany the scientific spirit.*

History affords no more remarkable phenomenon than the retrograde movement in civilization which began with the decline of the Roman power and continued through more than a thousand years. There had once existed a wonderful Greek civilization, but for twelve or fifteen centuries it was so nearly suppressed as to be without serious influence upon the life of the European people. Greek literature, one of the world's priceless possessions, not surpassed by the best modern literatures, was as complete two thousand years ago as it is today. Yet, in the middle ages, if we except a few scattered churchmen, it was lost to the European world. A Greek science never existed. Now and then, it is true, a Greek philosopher taught that the earth is round, or that the earth revolves around the sun, or speculated upon the constitution of matter; but excepting the geometry of Euclid and Archimedes, we say that nothing was proved, and that no serious efforts were made to obtain proofs. There could be no scientific spirit in the Greek nation and Greek civilization so long as the Greek religion lived, and the Greek people and government consulted and were guided by the oracles. If there had been a Greek science equal in merit with modern science, think you that stupidity and superstition could have secured a stranglehold upon Greek civilization and have maintained a thousand years of ignorance and mental degradation. Intellectual life could not prosper in Europe so long as dogma in Italy, only three hundred years ago, in the days of Bruno and Galileo, was able to say, "Animals which move have limbs and muscles; the earth has no limbs or muscles, therefore it does not move;" or as long as dogma in Massachusetts, only two hundred and fifty years ago, was able to hang by the neck till dead the woman whom it charged with "Giving a look towards the great meeting house of Salem, and immediately a demon entered the house and tore down a part of the wainscoting." The morals and the intellect of the world had reached a deplorable state at the epoch of the Borgias. It was the re-birth of science, chiefly of astronomy, as exemplified by the work of Columbus and Copernicus, and secondly the growth of medical science, which gave to the people of Europe the power to dispel gradually the unthinkable conditions of the Middle Ages.

It has been said that we may judge of the degree of civilization of a nation by the provision which the people of the nation had made for the study of astronomy. A review of the present-day nations is convincing that the statement represents the approximate truth. It is essentially true even of sections of our own country. In our first years

*This and the following paragraph have been taken, with but few changes, from one of my earlier addresses.—W. W. C.

as a nation a few telescopes were in private hands, here and there; they were used merely for an occasional looking at the stars. There were no observatories in the United States; no telescopes suitably mounted and housed for the serious study of the stars. The founding of the third American observatory, at Hudson, Ohio, about 1839, only a year or two after the completion of the second observatory at Williams College, Massachusetts, was an admirable index to the intellectual outlook of the Western Reserve.* The laying of the corner stone of the Cincinnati Observatory in 1843, a wonderfully ambitious institution for its day, was an event considered by Ex-President John Quincy Adams to be worthy of a hard trip, in the seventy-seventh year of his life, by rail from Massachusetts to Buffalo, by lake steamer to Cleveland, by four days of miserable canal boat to Columbus and thence on to Cincinnati, to deliver the formal address—then called an oration. Adams' task was, to quote his words, "To turn this enthusiasm for astronomy at Cincinnati into a permanent and persevering national pursuit, which may extend the bounds of human knowledge, and make the country instrumental in elevating the character and improving the condition of man upon earth."

Our former slave states have today only one active observatory, at the University of Virginia, presented by McCormick of Chicago. Barnard and other astronomical enthusiasts, born and grown to manhood in the South, have found their opportunity in the great northern observatories. Dr. C. P. Olivier, now at University of Virginia, is a notable exception. What is true of astronomy in the South is true, in general, of the other sciences. This unfortunate result is the natural product of the false, unscientific system of labor which, prevailing through many generations, taught that it is undignified for the white man to eat bread by the sweat of his own brow. Financial recovery, following 1865, has accordingly been slow. The future will correct this, for the men of the South are our blood brothers. We should be, and are, sympathetic.

Shall we try to estimate what astronomy, the oldest of the sciences, sometimes called an ideal and unpractical science, has done for mankind? Here are some of the applications of astronomy to daily life:

Observations of the stars with the transit instrument, such as exist in this observatory, are supplying the nations with accurate time. Two astronomers, with modern instrumental equipment, situated on the same north and south line, may observe the stars so accurately, in comparison with the beats of their common clock, that they will agree within two or three hundredths of a second as to how much that clock is fast or slow.

The accurate maps of the continents and islands depend upon the astronomical determinations of the latitudes and longitudes of their salient features.

*The northeastern part of Ohio constitutes the "Western Reserve."

The sailing of ships over long courses say from the Golden Gate to Sydney, Australia, or from New York to Cape of Good Hope, depend upon the A B C's of astronomy. Given fair skies, the navigator may locate his ship in the middle of the broad ocean within a mile of its true position.

In America it is the habit to call upon the astronomers to fix the boundary lines between nations, by observations of the stars; for example, along the forty-ninth parallel of latitude, from Rainy Lake, Minnesota, westward almost to the Pacific Ocean. The uncertainty as to where this imaginary line falls upon the ground is nowhere greater than ten or fifteen feet and it has not been found necessary by us, or by our friends in Canada, to maintain military forts along that line.

The times of high and low tides, vital to mariners in entering many harbors, are determined by or from the work of the astronomers.

We do not dwell upon these responses to the immediate needs of the world, for they are unimportant in comparison with the contribution of the pure knowledge side of astronomy to progressive civilization.

Let us think of the earth as eternally shrouded in thick clouds, so that terrestrial dwellers could never see the sun, the moon, the comets, the stars, the nebulae, but not so thick that the sun's energy would fail to penetrate to the soil and grow the crops. Under those conditions we might know the earth's surface strata to the depth of a mile or two. We might know the mountain and the atmosphere to a height of four or five miles. We might acquire a knowledge of the oceans, but we should be creatures of exceedingly narrow limits. Our vision, our life would be confined to a stratum of earth and air only four or five miles thick. It would be as if the human race went about its work of raising corn for food and cotton for raiment, always looking down, never looking up, knowing nothing of the universe except an insignificantly thin stratum of the little earth. This picture is only a moderately unfair view of life as it existed on our planet four hundred years ago, before the days of the telescope, the spectroscope, and the photographic plate and before the days of freedom of speech and thought which came with the scientific spirit. The earth is for us no longer flat, supported on the back of a great turtle, which rests upon nothing. It is round, and every civilized person knows that it is. Exists there an intelligent man in the world whose thoughts, every day and many times a day, are not unconsciously adapted to this fact? This knowledge is a chief inheritance of the generations. It is fundamental in our civilization. People know that the sun will rise in the morning and set in the evening, and why. A round earth, rotating upon its axis in a dependable way and revolving around the sun in exact obedience to law, are truths incomparably more sublime than the fiction of the flat earth which was pictured hazily in men's minds during pre-Copernican days. Who can estimate the value of this knowledge to the human race? It cannot be expressed with the few figures which suffice for the total of present day financial transactions.

The stars are not lanterns hung out in the sky by angels at night, but something inconceivably grander, they are suns, hundreds of millions of suns, each on the average comparable in size and brightness with our sun. Is not this ascertained fact of nature a most ennobling one to aspiring souls? Do not these facts suggest and develop becoming modesty in the minds of those who would know the truth and pattern their lives in accordance with it?

The following conversation occurred one Saturday evening in the month of June, 1912, at the eye-piece of the great telescope which Mr. Warner and Mr. Swasey constructed and erected for the Lick Observatory: I mention the time, June, 1912, because it is of the essence of the story.

Said the astronomer to the party of visitors: "The object which you will see through the great telescope this evening is the star cluster in Hercules, the finest cluster in the northern sky. Without the telescope, by naked eye, this cluster may be seen if the observer knows exactly where to look and has first-class eyes, but he will see it as apparently a single star on the limit of vision, so faint that many eyes will not see it at all. The telescope separates the cluster into a multitude of stars. If you had time to count them, they would number fully six thousand, closely grouped in the center of the cluster, but thinning out as you approach its edges. This one object, then, which to the naked eye seems to be a single star on the limit of vision, consists of at least as many stars as the eye alone is able to see in the sky as a whole, northern and southern skies, summer and winter skies combined, and we do not doubt that long photographic exposures on the cluster, with a large reflecting telescope, would record many more than six thousand. Each of these stars is a sun, and probably every one of those which you will see is larger than our sun, for we are observing merely the brightest members of the system. We do not know whether these suns have planets revolving around them or not, as the cluster is entirely too far away for us to see such planets, but planets probably exist there in great numbers; possible there are planets revolving around all of those stars; possibly and probably there are moons revolving around the planets; and, finally, there may be life, vegetable, animal, intelligent life upon those planets."

One of the visitors, upon descending from the observing chair, much interested, questioned the astronomer: "Did you say those stars are all suns?" "Yes, sir." "Did you say that those stars are really larger than our sun, on the average?" "Yes, sir." "Can you give me an idea how large our sun is?" "Well, if it were a hollow shell of its present size, you could pour more than a million earths into it, and there would still be much unoccupied space between the earth balls." "You say there are possibly or probably planets revolving around many of the cluster stars?" "Yes, sir." "And many of those planets may be inhabited?" "Yes, sir." "Well then, I think it does not matter very much

whether Roosevelt or Taft is nominated next week at the Chicago Convention."

Of course the visitor's interest in the outcome at Chicago was just as keen as ever, but he had evidently received a valuable lesson concerning man's place in nature.

The wonders of our sun are many and most remarkable, and are but little known. I have referred to its enormous size. The quantity of heat which the sun is radiating into surrounding space, to the earth, to Mars, and to all other objects which intercept its rays, is stupendous and not to be comprehended by the astronomer or the man of affairs. It is, and has been, the source of all energy upon which we draw, save only a negligible residual. A great quantity of heat is indeed stored up in the interior of the earth, but it reaches the earth's surface in such minute quantities that in all practical details of life, save to those who labor in deep mines, or live near volcanoes, or are interested in hot springs this source of energy may be neglected. If this statement should be difficult to accept, let your thoughts travel to the south pole of our planet. What does the interior heat of the earth do for that region? The antarctic continent's perpetual covering of ice and snow is unaffected by it, nor does the actually enormous quantity of solar heat falling upon that continent suffice to remove the white mantle. If ought should intervene to cut off the sun's energy from the earth for one short month, the tropics would attain to a state of frigidity to which the south polar continent, as now observed, would be a rose garden in comparison.

It is the sun's heat which grows the farmer's crops, the trees of the forest, and all vegetation. The coal deposits upon which we draw today for the running of trains, ships, factories and rolling mills, are but the solar energy of an earlier age, compressed, transformed and preserved for our comfort and power. In the mountainous regions of our land, where water can be stored in high level reservoirs, and, passing through water wheels at lower levels, be made to generate electric power for lighting, for heating, and for the running of motors, it is the sun's energy which is transformed to meet the needs of man. The sun's rays evaporate the surface waters of the oceans, lakes, streams, and lands; the winds, generated by the unequal solar heating of our atmosphere, transport some of the water vapor to the high mountains, where it is deposited as rain or snow. It is merely the descent of these waters to the lower levels that is controlled by man and transformed into electric power for his own purposes.

It would take more than two billion earths placed side by side to form a continuous spherical shell around the sun at distance equal to the earth's distance, and thus to receive the total output of solar heat. Therefore less than one two-billionth part of that output falls upon the earth. The earth's share of solar energy, expressed in horse power or other familiar units, it too great to set down in figures. If you should happen to own two hundred and fifty acres of land in one

of the tropical deserts of the earth, you will be interested to know that your quota of the solar energy, near the middle of a summer day, is falling upon your tract of land at the rate of about one million horse power—more than enough heat and power to supply all the needs of this great city—and this is but two-thirds of the sun's good intentions toward you, for some forty per cent of the energy is intercepted by the atmosphere overlying your farm, and returned forthwith to outer space.

Your neighbor's tract of two hundred and fifty acres is also receiving solar energy at the rate of one million horse power. Figuring backward, if one farm area receives a million horse power, and there are more than a hundred million such farm areas on the earth turned toward the sun at one time, and the whole earth intercepts less than one two-billionths of the sun's energy output, is it any wonder that sun worship became one of the recognized religions? Accurate knowledge saves us from that, but it is becoming in us to give the sun our due respect.

A great problem ahead of the scientific world is the storage of the sun's beneficial heat rays for release as needed. Astronomers are seeking intently for the sources of the sun's outpouring of energy: How can the sun maintain the supply for ten millions of years, as it undoubtedly is doing? One important source has been found—the sun's own gravitation which tries constantly to pull every particle of its material to the sun's center—but another and greater source seems to await discovery. Does anyone say since the supply of solar energy will surely meet our needs for ten or a hundred million years, why look further for the cause? Why not let go at that? This selfish spirit, if applied to all subjects, would retrograde our civilization. Even the possession of the truth is not so potent for good as the desire to know the truth and the struggle to discover it. Practically, a knowledge of the origin of the sun's heat may be the key for locking up great quantities of it on summer days, and unlocking it when and where needed.

Who is not interested in Mars, a planet much smaller than the earth, a little over four thousand miles in diameter, which revolves around the sun in somewhat less than two years, at an average distance from the sun fifty percent greater than the earth's distance? Mars is literally one of the earth's brothers, and we should be sincerely interested in his welfare. Does life exist on that planet? Almost certainly there is vegetable life. We have no reason to doubt it. Certain areas of the planet change in color as the climatic seasons come and go, very much as we should expect if those colors were controlled by the natural stages of vegetable life. However, in precaution, I should guard against the drawing of the conclusion that vegetable life on Mars has actually been proved to exist. I can merely say that we see no reason to doubt its existence. Is there animal life on Mars? There probably is, but we have no positive evidence that such is the case. If the

physical conditions on the planet as to water, air, and soil are such that vegetable life may exist, the chances are strongly in favor of animal life, also. However, I think we must leave unanswered, for the present, the question whether such animal life is highly intelligent. The forests of the St. Lawrence valley and the prairies of the Mississippi valley put on their green coats in the spring and changed them to brown coats in the fall, perhaps even better before the coming of man than after his destructive influence descended upon them. If you had the means to ascend several thousand miles above your present position, and could dwell there throughout the year, you would witness the formation of a polar snow cap upon the earth early in the autumn. The southern edge of this cap would extend farther and farther to the south up to the time of mid-winter. Its edge would extend well down toward the southern limits of the United States, to the Himalayas in Asia, and so on. With the coming of spring the north polar cap would decrease in size and probably disappear, save as to snows on the higher mountains and the possible ice and snows of the immediate polar regions. An observer similarly situated over South America would witness similar phenomena, as to the south polar regions; and these are indeed the phenomena observed on the planet Mars. The white polar caps on Mars wax and wane with the coming and going of the winter as they do upon the earth. Superficially, the Martian conditions seem not very different from the terrestrial, though we know that the Martian atmosphere is highly attenuated, and if we were suddenly set down upon the planet's surface we should certainly suffocate for lack of air. Water is probably scarce upon that planet in similar degree. However, these facts do not militate strongly against animal life upon Mars, for such life would undoubtedly be developed with respiratory and other organs adapted to their environment. A solution of the Martian problem, as to a possible counterpart of terrestrial man on that planet, is apparently not now hopeful, but present-day failures may be the prelude to future successes, and I prefer to offer no discouragement.

The planet Venus, only a shade smaller than the earth, and but two-thirds as far from the sun as we, presents a similar, but apparently more difficult problem. We know that it has an extensive atmosphere, no doubt comparable with that of the earth, but concerning the presence of water, we are justified in making no statement other than that we remain in apparently total ignorance. If Schiaparelli was right, as he appears to have been, that Venus always presents the same face to the sun, just as the moon always turns the same hemisphere toward the earth, then one hemisphere of Venus undoubtedly remains intensely hot in perpetuity and the other hemisphere in perpetual darkness and excessively low temperature. Can the twilight zone between the hemispheres of day and night offer abode and comfort to living forms, vegetable and animal? We have found no answer to this question, and we know not how to progress to the solution.

Are the moon and Mercury inhabited? Certainly not by such forms of life as we are familiar with, for neither object has an appreciable atmosphere. Both bodies undoubtedly suffer from extremes of heat and cold without the protecting blanket of atmosphere with which the earth is blessed.

The other planets, Jupiter, Saturn, Uranus, and Neptune, may be dismissed as uninhabitable by life forms of our acquaintance. There seems no reason to doubt that these great bodies, from four to eleven times the earth in diameter, are still devoid of solid footing for man or beast, such as the rock and soil strata afford upon the earth.

Have astronomers been able to prove that planets revolve around other suns than ours? No, the distance of even the nearest stars precludes that possibility to our means in hand. Such planets would need to be many-fold brighter than Jupiter, the greatest of our planets, and our great telescope would need multiplication many times in diameter to let us see them as attendants of their suns. We are able to prove, and have proved, however, the existence of hundreds of bodies, in distant space, whose rays of light we have not perceived. The spectrograph has shown with certainty that, of the naked eye stars, one in four on the average is not the single star which it appears to be to the naked eye, or when viewed in the telescope, but that it is a double sun, the two bodies revolving continually about their mutual center of mass. These hundreds of binary systems are so far away that even under the highest telescopic magnification they blend into a common and essentially mathematical point. It is the expectation that the future, possibly the present century, will establish that one star in three, on the average, is a double star system. It may even prove to be the truth that our solar system, consisting of one great central sun and many attendant planets, is not the average and prevailing system, but is the exception. However, we have no good reason to doubt that tens of thousands, more probably tens of millions of distant suns, are the centers of planetary systems, and that countless planets are the abode of life. As our sun is but one of hundreds of millions of suns, it is absurd and essentially inconceivable, that our planet, or two or three of our planets, should be the only bodies throughout the universe supporting life. It is vastly more probable that if our vision could penetrate to other stellar systems, lying in all directions from us, we should there find life in abundance, with degrees of intelligence and civilization from which we could learn much, and with which we could sympathize. The spectroscope proves absolutely that dozens of chemical elements in the earth's surface strata exist in our sun; that iron, the silicon of our rocks, hydrogen, helium, magnesium, and so forth, exist in the distant reaches of our stellar systems. If there is unity of materials, unity of laws governing those materials throughout the universe, why may we not speculate somewhat confidently upon life universal?

In the days of my youth, here in northern Ohio, the opinion prevailed

throughout my community, and widely over the earth, that comets were the forerunners of war, plagues or other forms of dire distress. Did not the great comet of 1811 herald the War of 1812, that of 1843 the Mexican War, and Donati's comet of 1858 our Civil War? Even in the twentieth century the fear that a comet may collide with the earth and destroy its inhabitants, comes to the surface here and there every time a comet is visible to the naked eye. The findings of astronomers concerning these visitors to our region of space have taught that we have nothing to fear from them, and that their close approaches may be welcomed, for they are interesting members of our sun's family. They revolve around our sun as the planets do, and render unto it homage and obedience. It is undoubtedly true that the earth has plunged through the tails of comets many a time, and without appreciable effect upon our health and happiness. In fact, the inhabitants have at the time been blissfully unaware of the passage. It is true that a collision of the condensed head of a comet with the earth is not impossible; it may sometime occur; but comprehensive studies of this question, based upon observational data concerning many of these bodies, lead indubitably to the conclusion that we must not expect these collisions to occur, on the average, more than once in fifteen or twenty million years. The so-called shooting stars, which we have all observed in the night sky, are in many cases, perhaps in all, though we do not know, the burning of minute pieces of comets which have disintegrated and as comets disappeared forever from our sight. Colliding with the earth, rushing through the upper strata of our atmosphere with speeds up to forty or more miles per second, the frictional resistance of the air heats them to the burning point, and they are turned to ashes and the vapors of combustion. A very few get through to the earth's surface, are found and placed in our museums. It is not certain that any of those in the museums are parts of disintegrated comets, but some of them probably are. The number of small foreign bodies which collide with our planet every day is very great; a conservative estimate is twenty million. Except for our beneficent atmosphere, man would suffer many tragedies from the bombardment. There is reason to believe that the earth is growing larger, slowly, very slowly, from these accretions, and this may have been the process from which the earth grew from a small nuclear beginning up to its present size.

Astronomers have determined that our solar system is very completely isolated in space. We are widely separated from our neighbors. I shall not try your patience by quoting the tremendous distances in miles, for they are incomprehensible to all of us. Rays of light sent out by the sun require a little more than eight minutes to reach the earth. The outermost known planet in our system, Neptune, would be reached in four hours and a half. Rays of light leaving the sun at the same time and traveling at the same rate, 186,000 miles per second, must travel continuously during four years and a half to reach our

nearest known neighbor in space, the bright double star Alpha Centauri. If the distance from the sun to the earth is 1, the distance to our outer planet is 30 and the distance to Alpha Centauri is 275,000. There appears to be an abundance of room in the great stellar system to meet the requirements of all. The spectrograph attached to the Lick telescope has determined that our sun and its family of planets is traveling through the great stellar system with a speed of twelve and a half miles per second, equivalent to four hundred million miles per year. The earth is certainly hundreds of millions of years in age, the sun is no doubt at least as old, and the early youth of the earth was lived, not where we are now, but far elsewhere in the stellar system; and its future journeying will lead to quite other points of observation.

The question of greatest interest to present day astronomers is that of stellar systems other than our own. The chances seem strong, that the hundreds of thousands of spiral nebulae known to exist in very distant space are other and independent systems of stars, many of them perhaps containing as many stars as our stellar system. In other words, our stellar system may be but one of hundreds of thousands of isolated stellar systems distributed through endless space. This is not an established fact, but the evidence seems to run in its favor.

I have referred to some of the problems and results of astronomical science. The list of interesting items is a long one, but available time has its limits. In brief, it is the astronomer's duty to discover the truth about his surroundings in space and make it a part of the knowledge of his day and generation. The ultimate and real value of his work lies in its influence upon the lives of the people of the world, in the changes for the better which it induces in their modes of thought, and in the impulse which it gives to an advancing civilization.

Would that the attractions of the sky to the average man were more potent! It is a curious comment upon the attributes of city life that hundreds of thousands of people, especially children, in London and Paris, in the darkness which gave them semi-concealment from the enemy's destructive air ships, should have obtained their first real vision of the starry heavens. What must have been their sensations? On the other hand, those who can view their beauties and wonders are prone to neglect them; to look down instead of up. Emerson has said somewhere in his immortal essays that if our sky should be clear of clouds but one night in a century, the people of this globe would look forward to the rare event, and not only prepare to behold its beauties themselves, but make sure that their friends far and wide were likewise minded. How the beauties of the night sky would surpass the expectations of the most lively imagination! The wondrous vision would be the prevailing subject of conversation for years and years, and the repetition of the vision, one hundred years later, would need no advertising.

Our knowledge of the heavens is in its infancy. We have but

made a start upon the discovery of the truth about the stars, and the results of astronomical research are not so widely known amongst the people as they should be. This splendid institution, The Warner and Swasey Observatory, presented by men who are masters in telescope and observatory design and construction, by men who have an intense love of the beautiful, both terrestrial and celestial, in their souls, by men who have thought much of relative values in life, this institution has a field of great usefulness lying before it. In their administration of the generous gift, the Trustees, the President and the Faculty of the Case School of Applied Science, whether for research, for school instruction or for community education, will have the sympathetic interest of astronomers, of all lovers of the truth. This observatory may assist in the solution of important problems concerning the universe of which we form a part. The universities, the colleges and the technical schools of our country and of other countries, are graduating every year, many hundreds of young men, ready to start upon the more serious stages of their lives who can tell us all about the lights in our home but not one word about the lights in our sky. This institution will do its quota in approximating to a liberal education. The casual visitor who enters its portals in search of knowledge, yea, the passer-by in the street who merely sees a dignified and purposeful observatory set upon a hill, will have his thoughts directed to higher levels.

PROPOSED PERIODS IN THE HISTORY OF ASTRONOMY IN AMERICA.

By W. CARL RUFUS.

(Continued from page 404.)

The Apparently Stationary Period, 1780-1830. The Revolutionary War interrupted the peaceful pursuit of science, but heroic efforts were made, especially by the Philadelphia astronomers, to continue their work. During the war eclipses were observed and in 1782 another transit of Mercury. At the death of Rittenhouse, 1796, the center and mainspring of the movement expired; and his observatory, the only one in the country, closed its doors.

Depreciation of the Apparently Stationary Period, however, should not go unchallenged. Foundation work in astronomy was silently progressing. A few of the old school kept alive the spirit of observational work by various minor activities on eclipses, comets and Jupiter's satellites; while a new generation of astronomers was forthcoming, foremost of whom was W. C. Bond in his private observatory at Dorchester, founded about 1823. At the same time Nathaniel Bowditch laboriously persevered with the translation of Laplace's "Mechanique Celeste," which he completed in 1817, although the first volume did

not appear until 1829. His explanatory notes comprised a real commentary on this classic, rendering it intelligible to readers of English with ordinary mathematical ability. He thus became the head of the mathematical school of astronomers in America, which has made valuable contributions to the subject.

Plans for observatories also indicated the progress of the foundation work. Thwarted again and again the campaign for a national observatory was continued from the time that Joel Barlow included it in his Prospectus of a National Institution 1806, by F. R. Hassler, James Monroe, William Lambert, J. Q. Adams and others, until success came in the following period. Plans were also in progress in Harvard College where corporate action was taken and Bond was commissioned to visit European institutions to study plans and instruments. The colleges also contained a rising generation of future astronomers. Olmstead at Yale succeeded in drawing about him a strong group of men, who helped to usher in the new period. From this institution came Chauvenet, Stanley, Mason, Loomis and Lyman. John Farrar at Harvard contributed to this movement by his teaching and his textbook, "An Elementary Treatise on Astronomy," 1827. Benjamin Pierce was one of his pupils. West Point also provided its full quota, —Courtenay, Norton, Mitchell and Bartlett.

From the days of Rittenhouse, astronomical contributions to American scientific organs constituted an important part of their publications. This work began with Volume I of the Transactions of the American Philosophical Society in 1771, which was chiefly astronomical. The orrery of Rittenhouse occupied first place. Much space was devoted to the transit of Venus. An interesting essay on comets by Hugh Williamson was also included. Not until 1786, after the war had subsided, did Volume II appear, which is also largely astronomical. The American Academy of Arts and Sciences founded in 1780 laid emphasis upon "Useful Knowledge," but many astronomical papers were published. The American Journal of Science, 1818, provided another organ of publication. Among other early astronomical contributors are Samuel Williams, Rev. James Madison, president of Williams and Mary, Andrew Ellicott, William Lambert, Joseph Willard, Manassah Cutter, and Benjamin West.

The impetus given to astronomy by the excellent work of F. R. Hassler, in the broad foundation plans of the Coast and Geodetic Survey deserves mention, although the war of 1812 and political complications postponed full fruition until the reorganization in 1832.

The continued interest of American statesmen in education and science from the time of Franklin and Washington also contributed to the foundation work by building these essentials of democracy into the fabric of American institutions. John Adams promoted the American Academy of Arts and Sciences, Jefferson served as president of the American Philosophical Society, J. Q. Adams is said to have prized the presidency of the American Academy more than the chief magis-

tracy of the nation. His special interest and effort in the campaign for a national observatory are noteworthy.

So we find that the Apparently Stationary Period witnessed real foundation work especially in the introduction of mathematical astronomy, in interest in observations and plans for observatories, in producing future astronomers, and in the sympathy and support given by the leading men of the nation.

The Popular Period, 1830-1860. We have placed the end of the Apparently Stationary Period of astronomy in America at an earlier date than other writers have set for the revival of intellectual activity. Silliman in the Priestly address gives 1845 as the date of the renaissance. Newcomb fixes it at 1840. Young from the standpoint of Astronomy gives 1836, the year of the founding of Williams College Observatory. Unmistakable signs of increased activity in astronomy, however, preceded 1830. The first volume of Bowditch's translation of Laplace appeared in 1829. The Clark gift at Yale was made and a 5-inch telescope ordered in 1828. Upon its arrival in 1830 and immediate application enthusiasm for astronomy was manifested not only in Yale, but also in many parts of the country. North Carolina established the first college observatory in the same year. The Depot of Charts and Instruments in Washington, subsequently the camouflage of astronomical activity, was so established in that year. A solar eclipse in 1831, the great star shower of 1833, and the predicted return of Halley's Comet in 1835, added to popular as well as scientific interest. The work of Olmstead and Twining on meteors and the discovery of Halley's Comet upon its return by Olmstead and Loomis before it was observed by European astronomers, indicate that astronomy in America was well launched on the new period before the middle of the decade. The great demand for Elihu Burritt's "Geography of the Heavens," 1833, requiring a third edition by 1835, and the unprecedented circulation of the New York Sun, due to the celebrated Moon Story by Richard Adams Locke in 1835, show that the popular movement was likewise in full swing by that time. We accordingly place the date of the beginning of the Popular Period at 1830.

The characteristic new movement in astronomy in America during this period was the beginning of practical astronomy. Holden* mentions Coffin, Hubbard and Walker as the fathers of (practical?) astronomy in the United States; but we give the palm in practical astronomy to James M. Gillis. From the standpoint of number and quality of observations he deserves first place. Records made in a little 13 x 14 ft. building, 1200 feet north of the Capitol, form the first volume of observations published in this country. Furthermore, although he was not the first director, his work as founder of the National Observatory at Washington, the first practical working observatory in the United States, establishes his supremacy in the field of pioneer practical astronomy in this country.

*Handbook of Lick Observatory, p. 116.

Two valuable contributions to practical astronomy were made by Americans during this period, the invention or reinvention and application of the zenith telescope to latitude determination by Talcott in 1834; and the invention of the chronograph and application to longitude determination in 1848 by the co-operation of several men including Wilkes, Bache, Walker, Locke, Saxton and Bond. These contributions adopted abroad were known respectively as the American method of latitude determination and the American method of longitude determination.

The rapid rise of observatories also characterizes this period. Following the lead of North Carolina, observatories were constructed in rapid succession at Williams College, Western Reserve, Philadelphia High School, West Point, Washington, Georgetown College, Cincinnati, Harvard, Amherst, Ann Arbor, Albany, Hamilton College and at other places by private owners.

Pioneer work in celestial photography owes much to Americans. J. W. Draper, G. P. Bond and L. M. Rutherford were the chief contributors. Time prevents us also from following the development of mathematical astronomy under Walker, Pierce and others, the success in instrument making by Yale students, and by Fitz, Clark, Spencer, Draper and Rutherford. In observational work American discoveries began to attract the attention of Europeans. Cometary discovery included the return of Halley's and the division of Biela's, which was first noted in America by Herrick and Bradley of Yale. Bond discovered Hyperion in 1848 and Saturn's dusky ring in 1850. In navigation Sumner's method, 1843, was the chief American contribution. The Coast and Geodetic Survey was reorganized in 1832 under Hassler, and his successor, Bache, drew about him a strong group of astronomers as advisers giving inspiration and direction to astronomical activity. Three astronomical periodicals were also founded, two of which were short lived, the Sidereal Messenger of Mitchell, 1846-48, and the Astronomical Notices of Brunnow, 1858-62; the third was the Astronomical Journal founded by B. A. Gould in 1849, published until 1861 and re-established in 1886.

During the Popular Period American Astronomy was well started on its building program, at least the first story was completed.

New Astronomy Period, 1860-1890. The rise of astrophysics is the characteristic movement. At the beginning of the period the popular interest was interrupted by war and the development of science in the United States was practically arrested. The American Association for the Advancement of Science, which under ordinary conditions held annual meetings, suffered a six years' intermission. Astronomical periodicals suspended publication. Astronomy lost one of its most ardent devotees, O. M. Mitchell, who died in service in 1862. Lieutenant Maury, director of the National Observatory, fled from his post at the outbreak of hostilities, leaving behind proof of treasonable correspondence. The undivided effort of the North was necessary to save

the threatened union. In the midst of hostilities the cause of science also suffered the loss of the Smithsonian building by fire. It is said that Lincoln, watching the flames, exclaimed, "Gentlemen, yonder is a national calamity. We have no time to think about it now; we must attend to other things."

The war brought an occasion, however, for the organization of men of science to give technical scientific advice to the government, a need pointed out by Bache in 1851, and met at that time of stress by the founding of the National Academy of Sciences in 1863. Papers presented in 1864 included astronomical numbers by Gould, Pierce and Rutherford.

The early work of J. W. Draper in spectrum analysis deserves greater credit than is usually given. In 1837 he discovered the ultraviolet region by photography, and according to Goode,* "as early as 1847 had already laid the foundations of the science of spectroscopy, which Kirchhoff so boldly appropriated many years later." However, it was not until 1859 that the movement took on special significance. L. M. Rutherford made an early classification of stellar spectra in 1862 preceding the work of Secchi. Two of his classes corresponded with two of Secchi's, but the third was based upon insufficient evidence due to deficient instrumental equipment. The work of classification done abroad by Secchi and Vogel was improved by Henry Draper and at his early death provision was made to continue the work at Harvard. Under the guidance of E. C. Pickering the excellent system known as the Draper classification was perfected, which has been adopted for international use. Draper was the first to succeed in photographing a stellar spectrum, that of Vega in 1872. The Draper catalogue of 10,351 stars published in 1890 concludes an epoch in the work of classification, which was one of the chief movements of the period. During the progress of the work it was noted that the great majority of the stellar spectra could be arranged in a linear sequence, beginning with bluish white and white stars, then passing through yellow to red, forming a continuous sequence showing intergrades for classes B A F G K M. This series became known as the Harvard sequence and Pickering interpreted it to represent a stellar evolutionary sequence.

Solar physics developed rapidly during this period. C. A. Young and Vogel independently measured the shift of lines due to the sun's rotation, thus establishing the Doppler principle on an observational basis. Young also detected the bright coronal line in 1869, photographed solar prominences in 1870, and discovered the reversing layer by observing the flash spectrum. Rowland with his concave gratings and Langley with his newly-invented bolometer advanced our knowledge of the sun by the application of these instruments.

During this period American astronomers made many important dis-

*The Beginning of American Science, p. 455.

coveries. Burnham began his work on double stars. The discovery of comets and the discovery of asteroids by Watson, Peters, and others, were eclipsed by the discovery of the dark companion of Sirius by A. G. Clark in 1862 and the more remarkable discovery of the satellites of Mars by Hall in 1877. This achievement was made possible by the excellent work of the Clarks on large lenses, another phase of the development of the period culminating in 1888 by the production of the 36-inch Lick refractor. One of the greatest features of the period was the invention and improvement of instrumental equipment. The gratings of Rutherford, the best produced in his day, were excelled by Rowland, who developed the ruling engine to a high grade of perfection. His concave grating made possible the excellent chart of the normal solar spectrum produced in 1885. Pickering's meridian photometer, the almucantar of Chandler and the bolometer of Langley also belong to the inventions of this period. The spectroheliograph of Hale was invented near the end of the period.

Mathematical astronomy was advanced by the work of Newcomb on planetary theory, while G. W. Hill made important contributions to lunar theory. Kirkwood, as early as 1861, suggested the cometary origin of meteoric swarms, a work more fully elaborated by H. A. Newton. The theory of eclipsing variables was proposed by Pickering in the study of the Algol system. S. C. Chandler, in addition to work on variables, attacked the problem of latitude variation, reaching valuable results in the following period. The Coast and Geodetic Survey corrected the adopted longitude difference between Greenwich and Paris and other important centers, thus establishing the supremacy of the American method of longitude determination.

B. A. Gould contributed the Uranometria Argentina in 1879. Valuable stellar parallax results were obtained by Elkin, Hall and others. The method of celestial photography was successfully applied to the stars, and the nebulae, and Barnard's excellent work on the Milky Way began in 1889.

The Sidereal Messenger, 1882-1891, was the only American astronomical periodical of the period, in addition to the Astronomical Journal suspended 1861-1886. We may close this rapid and incomplete summary of the period by mentioning the organization of the Astronomical Society of the Pacific in 1889.

The position of America in astronomy was firmly established during the period. At the Paris Conference in 1887 Simon Newcomb, recognized leader in this country, occupied a high position of influence and authority. International co-operation in astronomy was beginning to function and America was prepared to take a prominent part.

The Correlation Period, 1890—. Much consideration has been given to fix the date and to select a designation for the last period. The work in astrophysics during the preceding period, the New Astronomy Period, was chiefly qualitative. Classification was the main contribution. About 1890 began a new movement which we have designated

"the beginning of Quantitative Astrophysics," lacking a better name. That movement made possible the determination of physical quantities as well as physical qualities of the celestial bodies, and provided a basis for the correlation of the results of the old astronomy and the new. So we venture to fix 1890 as the date and to adopt the name, the Correlation Period.

Among the most important applications of the quantitative method are the determination of radial velocity, the orbits of spectroscopic binaries, parallax by the spectroscopic method, the quantitative method of spectral classification, the measurement of radiation from the stars, and last but not least, the determination of the size of a star by means of the interferometer, as announced at the 1920-21 session of the American Association by Professor Michelson, by a method which also had its origin in 1890.

Another characteristic feature of this period is the construction of a new type of large observatories, which may be said to have begun with Lick in 1888, followed by Lowell, Yerkes, Ann Arbor, and Mt. Wilson.

The classification of stellar spectra has completed another stage. Pickering added classes O, P and R for the Wolf-Rayet stars, gaseous nebulae and carbon stars with more than ordinary intensity of violet light. The Henry Draper catalogue containing 222,000 stars is now in process of publication, the first volume having appeared in 1918.

Campbell and Kapteyn independently found in 1910, by correlating radial velocity with the stellar sequence, that velocity is a function of spectral class. Other correlated quantities are temperature, color index, distribution with reference to the galaxy, percentage of binaries, eccentricity of their orbits, separation of components, length of period, percentage of variables and length of period of variability.

The correlation of absolute magnitude with the Harvard sequence by Russell, following Hertzsprung, and subsequent work at Mt. Wilson and elsewhere shows that the so-called later types are divided into two classes, giants and dwarfs, and has given rise to a new theory of stellar evolution with the red giants at the beginning of the series on an ascending temperature branch, which passes through yellow and white stars to the maximum, then descends in the opposite order with red dwarfs at the end.

American astronomical discovery has kept pace with the advance in other lines. Jupiter's fifth satellite was discovered by Barnard, 1892, the sixth and seventh by Perrine, 1904 and 1905, the ninth by Nicholson in 1914. Saturn's ninth and tenth are credited to W. H. Pickering, 1899 and 1905. Aitken and Hussey have maintained America's lead in double star discovery and measurement.

The final period has also been characterized by co-operation in astronomical work which has paved the way for broader co-operation in research, international in its scope. We can merely mention the part taken by Dudley, Washington and Harvard observatories in the Astronomische Gesellschaft catalogue, the founding of the International

Solar Union, the precursor of the International Astronomical Union, and the culminating organization of the International Research Council in which American astronomers were especially active and prominent. When the artificial and unscientific bars put up by the Allies are removed and the scientists of the Central Powers are admitted and give support to the organization, a world scientific consciousness will be the result.

This brief survey indicates that at the beginning America was a debtor to astronomy for the part it played in discovery and to the old world for transplanted scientific ideas. American astronomers have now reached a stage in which the debt may be paid, at least in part, not merely by their valuable contributions to the science of astronomy; but also by their leadership in world organization for scientific progress, they may pave the way for a broader world union for the welfare of mankind.

NOTES CONCERNING THE PONS-WINNECKE COMET AND METEORS.

By O. H. TRUMAN.

While the shower of meteors which might have been expected, at the recent approach of the earth to the orbit of the Pons-Winnecke comet, did not materialize, yet some facts concerning the comet and meteors, which I gathered in making preparations to photograph them, may be of interest to the readers of POPULAR ASTRONOMY.

In order to gain a more accurate idea of the relation of the earth's orbit to that of the comet, I made a model showing the small portion of each orbit with which we are concerned, to a scale of two inches to the million miles. A photograph of this model is given in Fig. I. The earth's path is shown by the wire in the center, parallel to the base; the wire nearest the observer is the comet's path at the present return, and the farther wire is the path at the return in 1915. The descending node line of the present orbit is drawn in, with spaces of a million miles marked off upon it; and the dates when the comet and the earth found themselves at various places are indicated.

The data for the present orbit are given by Einarsson and Meyer, in *Lick Observatory Bulletin* No 331, and are no doubt very close to the truth. In 1915, on the other hand, the comet was very badly placed, and, being regarded as of slight importance anyhow, was but little observed, and I could not find an orbit based directly on measured positions. However, E. Waage has given, in *Astronomische Nachrichten* No. 4787, an excellent orbit for the return of 1909, and brought

it forward to 1915 by computing the perturbations of Jupiter. The result should be accurate enough for our purposes.

The first thing noticed is the great alteration in the comet's path between the two returns. The line of nodes has obviously regressed; the inclination has slightly increased, though not enough to show in the photograph, and the distance of the comet from the sun, in this part of its orbit, has increased by about 6½ million miles.

Also it is seen that we are to pass only about two-thirds as far from the comet's orbit at the present approach as we were in 1916—the distances being 2.7 and 3.8 million miles respectively. And, finally, we were to come very close behind the comet—only about nine days be-

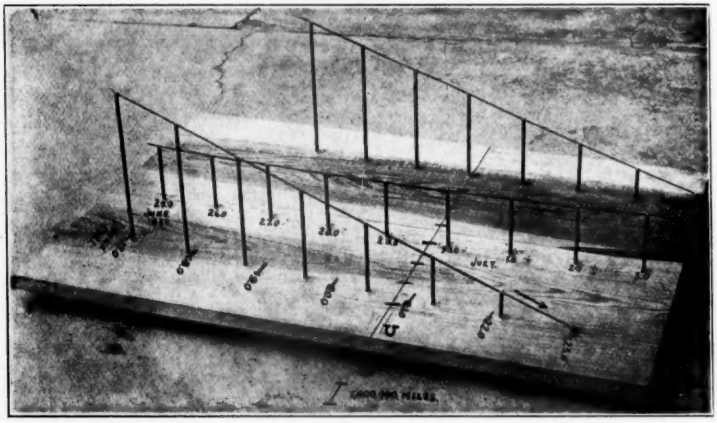


Fig. 1.

Model showing the orbit of the Pons-Winnecke comet in 1915, (furthest) in 1921, (nearest) and of the earth, (middle) in the region of close approach.

hind, in fact, while on the previous occasion, while the earth reached this region in late June, as now, the comet had already passed it ten months before, in early September of the previous year.

All these circumstances seemed to promise a far greater display of meteors than we had in 1916; and the shower then, while by no means striking to the layman, was exceedingly so to meteoric observers, some of whom reported a rate on one night, June 28, of one meteor per minute or better.

There was, however, one disturbing consideration. If the meteors were distributed behind the comet in a gradually expanding cone, then for us to come so close behind as we were coming this year, while yet being at a considerable distance from the orbit, would mean that we would miss them entirely. And, though from absence of previous experience one could not have predicted it in advance, this appears to be what occurred. For the point in the sky from which the meteors would

PLATE XXIII

North

East

Fig. 2.

Photograph of the Pons-Winnecke Comet
at a distance of 13¼ million miles.

The small dot at the lower left, with the arrow pointing to it, is the earth drawn to the same scale.

The arrow at the lower right shows the direction of the comet's motion.

Photographed at Lowell Observatory, June 16, 1921, with a lens of 5-inch aperture and 35-inch focus. Exposure 1 hour.

seem to diverge could be easily computed; and in several hours of watching on nights during our nearest approach to the orbit I saw only three or four meteors which might have belonged to this radiant, and these could have easily come by coincidence. When the reports of many experienced and persistent observers are collected, it may appear that we got a few meteors from this comet; but it is certain there was no conspicuous shower.

The causes which bring about the disintegration of a comet into an extended meteor swarm, and the manner in which the meteors will become distributed behind the comet, are of an unknown character. It seems probable that disintegration is brought about by similar forces to those which have on several occasions made a comet split up while under observation; but I think it is unlikely that gravitation alone, to which the phenomenon is often ascribed, could accomplish it. It is easy to compute that in the absence of internal forces of some sort to hold a comet together, it would go to pieces by the pull of the sun alone in less than a single revolution; but whether these forces are entirely gravitational, and, if they are, why they sometimes fail, are questions to which only an extensive mathematical investigation can point the answer.

It is worth while to notice that the shower of 1916 did not come at the time of our least distance from the orbit, on July 2 and 3, when we were about 3.8 million miles away, but rather four or five days earlier, when we were 0.6 million miles farther off. If meteors were equally well looked for on all the nights in question, this would show that they were distributed in bunches behind the comet, rather than uniformly, a thing by no means improbable; but as the shower of 1916 was not expected, it may be that it happened on other nights as well as that of June 28, but was not noticed.

As for the comet itself, Plate XXIII is a photograph I made on the morning of June 16, when it was practically as near to us as it came—about 13¼ million miles away. The original picture shows a well-marked nucleus; but I have had to sacrifice this in order to bring up the fainter parts. The rapid motion of the comet among the stars, in the direction of the arrow in the lower right, is conspicuous.

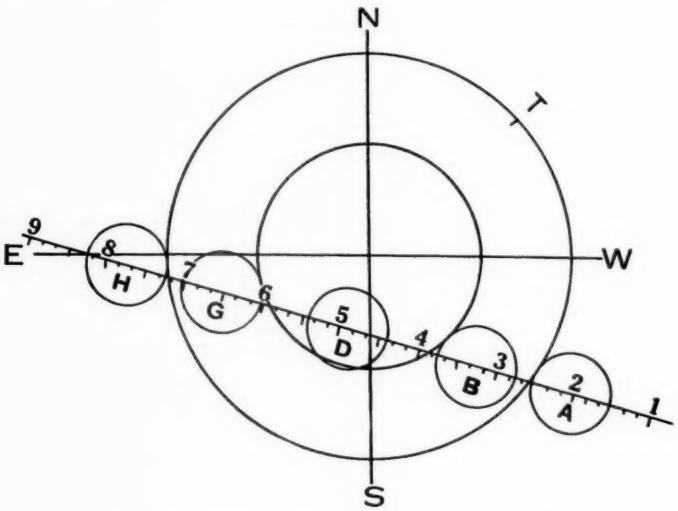
To show how large compared to the earth is even this very insignificant comet, I have drawn the earth to the same scale at the lower left, with the arrow pointing to it. One can see that the dense part of the coma is about twice as big as the earth, while the fainter portions are four times as big; and doubtless if I could have given a longer exposure still fainter and larger parts would have appeared.

Lowell Observatory.
July 23, 1921.

ECLIPSE OF THE MOON, 1921, OCTOBER 16.

By WILLIAM F. RIGGE.

Although the eclipse of the Moon of next October 16 will be a large one, 0·94, it will pass almost unnoticed or unnoticeable on account of its too early occurrence. The anexed drawing shows that the Moon, B, will enter the Earth's shadow at 3:14 P. M. central time. As the Moon will rise only at 5:42 at Omaha, or about 4:12, central time, at New York, the beginning of the eclipse will not be observable anywhere in the United States. The middle, D, will occur at 4·54. The Moon, G, will leave the shadow at 6:34, just as it begins to rise on the Rocky Mountains. As the Sun will set when the Moon rises, the eclipse, as said, may be not noticed at all.



A—Moon enters Penumbra	2:01
B—Moon enters Shadow	3:14
D—Middle of Eclipse	4:54
G—Moon leaves Shadow	6:34
H—Moon leaves Penumbra	7:46

Central Time P. M.

THE EFFECT OF THE BAROMETRIC GRADIENT ON MERIDIAN OBSERVATIONS[1].

By CHARLES CLAYTON WYLIE.

Anomalous refraction, due to inclination of the atmospheric layers of equal pressure, has been discussed in astronomical publications for many years. Perhaps most of the unexplained systematic errors of astronomical work have at different times been attributed to this or similar effects.[2] The error introduced by such a tilt of the air strata is the difference between the refraction computed using the zenith distance from the normal to the air strata and that computed in the usual way using the zenith distance from the vertical.[3] With sufficient accuracy for this investigation the error can be assumed to vary in hour angle as sec z sec δ and in zenith distance as $\sec^2 z$; z being the zenith distance and δ the declination of the object observed.

The Washington observations of the Paris-Washington longitude campaign were selected as suitable for the investigation.[4] Zenith stars were observed; and test computations indicated that the mean error for each night due to tilted air strata would be, with negligible error, the anomalous refraction at the zenith.

A solution was carried through to obtain from the night residuals the anomalous refraction at the zenith due to the barometric gradient scaled from the Weather Bureau maps. The resulting value made no appreciable improvement in the residuals and was opposite in sign to theory. The barograph records were also examined in an attempt to connect the change in the residuals with the rise or fall of the barometer, but no success was attained.

Since the effect should theoretically be greatly magnified at low altitudes, the writer wrote to the U. S. Naval Observatory for observations made with the 6-inch transit circle at zenith distances over eighty degrees. Mr. J. C. Hammond kindly furnished one hundred such observations for declination. Where a north star was observed immediately after a south, or vice versa, the residuals of the pair often show a small effect such as tilted air strata would produce. For example,

[1]Read at the twenty-fifth meeting of the American Astronomical Society, Chicago, Ill., Dec. 29, 1920.

[2]"The so-called anomalous refractions which have been made to serve as the explanation of so many discordances in observations. . . . " Comstock, Astronomy and Astrophysics, **13**, 340, 1894.

"The observer . . . who has a whole night's observations to stand out widely from the mean of the entire work for no explainable reason may clear up some of his difficulty by a look at the weather map." Conrad, POPULAR ASTRONOMY, **25**, 524, 1917.

See also Young, General Astronomy, Art. 91; Tucker, Lick Observatory Bulletin, **323**, 51, 1919.

[3]Comstock, Publications Washburn Observatory, **9**, 196, 1896. Schlesinger and Blair, Publications Astronomical Society of Pacific, **18**, 46, 1906.

[4]Publications U. S. Naval Observatory, **9**, Appendix.

eight observations were obtained in 1914 of the pair, γ Ursae Majoris lower culmination, altitude 3°.1, and α Phoenicis, altitude 8°.3. In six of the eight the residuals in zenith distance have opposite sign. When the north star appears low, the south star appears high, and vice versa, as we would expect in inclined air strata. No relation, however, was apparent between this supposed tilt and the barometric gradient scaled from the Weather Bureau maps. Near the zenith we found the error to vary as $\sec^2 z$. An examination of the residuals communicated by Hammond leads to the conclusion that if this formula holds even approximately at low altitudes, the anomalous refraction at moderate zenith distances does not exceed a few hundredths of a second of arc.

To find the error one should expect from the barometric gradient, the anomalous refraction at the zenith coresponding to the gradient scaled from the Weather Bureau maps was computed for several nights on which astronomical observations were made. The gradient over Urbana was used for about forty nights, on which photometric observations were made; and that over Washington for about sixty nights, on which transit observations were made. The maximum value for the anomalous refraction was about one hundredth of a second of arc, an error too small for consideration in ordinary meridian circle or zenith telescope work.

A similar computation was then carried through in reverse order to find the barometric gradient which would produce the errors of observation of the Paris-Washington longitude work. The probable error of a single night was $0^s.0124$, and the largest night residual $0^s.061$. The corresponding gradients would mean a change in the barometric presure of a tenth of an inch in seven miles for the probable error, and a tenth of an inch in 1.4 miles for the largest residual. In a conversation with a government climatology expert of Washington, D. C., the writer was told that this is the gradient of a tropical hurricane. Being about one hundred times that usually shown on the maps in observing weather, local conditions could hardly produce it without stopping astronomical work.

By every method, then, our investigation indicates that, at moderate zenith distances, anomalous refraction of this type must be exceedingly small. Observers should look elsewhere for the source of troublesome systematic errors. This is in agreement with other recent results.

Zimmer[5], of Cordoba, consulted the weather maps in an attempt to explain some of the larger residuals in his meridian circle work, but "met with little success". Comstock[6] computed differentially the error in the refraction formula for abnormal meteorological conditions. His result was that plausible changes in atmospheric conditions would introduce an error of several minutes of arc at the horizon, but of less than a second at four degrees altitude and of only a few hundredths

[5]Astronomical Journal, **32**, 1, 1919.
[6]Publications American Astronomical Society, Twenty-third meeting, p. 83.

of a second of arc at zenith distances less than seventy-five degrees. Littell's[7] recent investigation of the Washington Photographic Zenith Tube results has just been called to my attention. He examined the barometric gradients for 1916 and 1917 and concluded that while small refraction effects due to tilted air strata were perhaps present, "they were not nearly large enough nor in satisfactory phase agreement to account for the Kimura term."

An earlier piece of work, and more extensive than any of these just referred to is that of Schlesinger, with Blair and Hudson.[8] The work of the international latitude stations, 1900-04, was investigated for the effect of anomalous refraction. For some of the stations, their solution gave an imaginary value for the effect. The value for the entire series of observations was real, but so small the investigators thought it could not be considered evidence that any error due to anomalous refraction was really present.

Some apparent evidence that the barometric gradient introduces troublesome errors has been found in short series of observations. But the more thorough investigations give such uniformly negative results that most of us will agree with the conclusion reached by Schlesinger and Blair in 1906 in the reference previously cited; that "this explanation for inconsistencies in meridian work should be advanced with caution".

University of Illinois Observatory,
December 1920.

A MODERN THEORY OF SPIRAL NEBULAE.

By GEORGE B. HUFFORD.

The place or order of the spiral nebulae in the visible universe is one which has caused much discussion. Professor Young positively asserts that the nebulae belong to our system and many of the ablest scientists have given it as their opinion that our system has a definite boundary and we are apprised of nothing beyond. Thus, in his book entitled "Man's Place in the Universe," Wallace says: "Evidence now adduced must be held to constitute, as nearly as the circumstances will permit, a satisfactory proof that the stellar universe, of which our solar system forms a part, has definite limits." He reaches this conclusion by quoting from Newcomb, Gore, Sir John Herschel, Professor Celoria and others.

[7] POPULAR ASTRONOMY, **29**, 21, 1921. See also Astronomical Journal, **33**, 123, 1921. These articles appeared after the reading of this paper in Chicago. The note in POPULAR ASTRONOMY was presented at the twenty-fourth meeting of the Astronomical Society in September, 1920, and my attention was called to it soon afterwards.

[8] Schlesinger and Blair, Publications Astronomical Society of Pacific, **18**, 46, 1906. Schlesinger and Hudson, Publications Allegheny Observatory, **3**, 55, 1913.

The opinions of these authorities have been generally accepted in their own time but astronomy has developed so rapidly that even the greatest authority may live to see some of his opinions discarded. The problem of the spiral nebulae is an example of this. The recent investigations by western observatories may cause us to revise our opinions concerning these nebulae.

Nebulae are classified according to their form into diffuse, planetary, ring and spiral. The diffuse may be of various dimensions without sharply defined form or systematic motion. The only thing we know about them is that they are composed of luminous gases. The planetary and ring nebulae are small compared with the former class but appear to be composed of the same materials with the possible addition of a central star. The spiral nebulae, on the other hand, appear to have a fundamentally different character as shown particularly by the investigations made in the last fifteen years at the Lick, Mt. Wilson and Lowell observatories. At one time, in the first half of the last century, the great telescopes of the Herschels and Lord Rosse resolved many supposed nebulae into clusters of stars and it began to be doubted if there were any truly nebulous objects. Sir William Huggins, however, demonstrated with his spectroscope that there are many such nebulous objects whose light indicated their gaseous nature, although he found that some, including the great nebula in Andromeda, gave a continuous spectrum. The recent discoveries by our western observatories seem to be giving us a new theory as to the fundamental nature of the spirals.

Professor Curtis of the Lick Observatory, in a lecture delivered in 1917 (Stahl Lectures) has given a number of reasons why the spirals are different from other classes of nebulae. The evidence comes both when the telescope is used as a camera and when used in conjunction with the spectroscope. The discovered facts are briefly these: 1. The velocities relative to the sun are vastly beyond those of the gaseous nebulae. 2. Spirals appear to be at great distances from our galactic system while at least some of the gaseous nebulae belong to it. 3. Their spectrum is not that of gaseous nebulae but the spectrum of a vast congerie of stars.

Professor Curtis, on examining two photographs of the great nebula of Andromeda taken two years apart, found that eleven novae had appeared within that period. (I have learned recently through Professor Aitken of the same observatory, that since the above date four additional novae have been discovered, making fifteen within this brief period.) A "nova" although it is called a "new star" is pretty generally considered an expiring star roused to new activity by some catastrophe, possible a collision. The evidence of these novae in connection with the three points mentioned above induced Professor Curtis to agree, tentatively at least, with the opinion that these spirals might be galaxies—"island universes" in the proces of formation. Indeed it is

hard to account for these numerous novae on any other score, as each no doubt represents some catastrophe.

If this view is correct it means that we have here vast clusters and universes of stars, the stars within which collide and crash as long as they get into each others way until a smaller number is left with comparatively clear paths. Those left would to a certain degree wipe up the debris of those that perished.

This, to be sure, is a mighty thought for a human being inhabiting this infinitesimal planet to conceive; still it is within his province to essay to do so. It concedes that our stellar universe is unstable; that through some process it was formed and that it will ultimately disintegrate, and, possibly, be reformed again, thus going through cycle after cycle. It also leads us to assume that space is unlimited, and in its depths in every direction there are perhaps universes without number.

The theory has long been held by many astronomers that each star is brought into existence by some cosmic process, that it lives its life, and then through the further applications of this same process is resolved into its constituent parts and later reformed so that there is a never-ending sequence. Furthermore, if the discoveries of our western observatories are confirmed, this theory must be extended to the galactic system itself and also to those distant galaxies which we know under the name of spiral nebulae.

Austin, Texas.

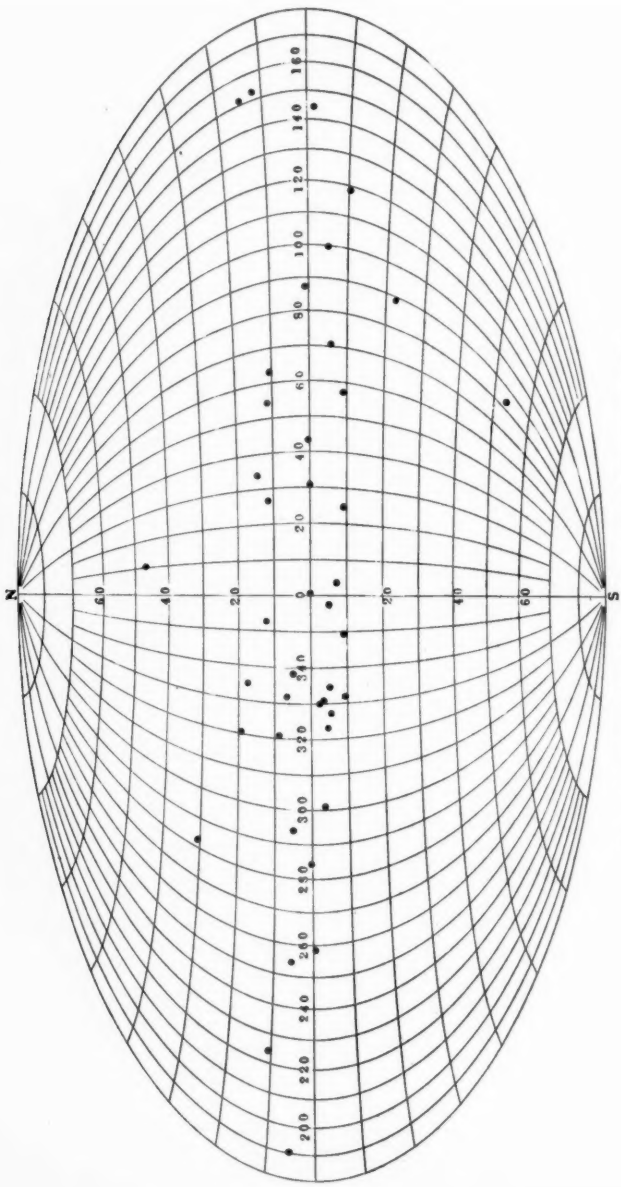
MISCELLANEOUS NOTES AND DATA RELATIVE TO NOVAE

By C. O. LAMPLAND.

In a paper sent to the Chicago Meeting (Dec. 1920) of the American Astronomical Society some material was given that was not mentioned in the abstract of the paper. That communication was devoted largely to observational results. The following notes and data appearing in different parts of it may be of interest to some readers.

A diagram is reproduced herewith showing the distribution of the novae with respect to the Milky Way. Thanks to the splendid work of the Harvard observers the number of temporary stars now exceeds forty, exclusive of the many faint novae discovered in nebulae. As is well known, and very evident from the diagram, these objects appear almost without exception in or near the Milky Way.

The following tables need no comments as the columns are sufficiently self-explanatory.



DISTRIBUTION OF THE TEMPORARY STARS REFERRED TO THE PLANE OF THE MILKY WAY
(Equal Area Projection)

Star	Year of outburst	Interval in years since outburst	Maximum brightness observed	Minimum brightness observed	Observed range of light variation	
			Mag.	Mag.	Mags.	Ratio of maximum brightness to minimum
Nova (Q) Cygni	1876	44	3.0	15	12	63,000
Nova (T) Aurigae	1891	29	4.5	14.7	10.2	12,000
Nova Persei (1901)	1901	19+	0.0	12.8-15	15	1,000,000
Nova Geminorum 1	1903	17+	5.1	16+	11	25,000
Nova Lacertae	1910	10	5.0	14.5	9.5	6,300
Nova Geminorum 2	1912	8+	3.7	13.5	9.8	8,300
Nova Monocerotis	1918	3—	5.4	15	9.6	6,900

COMPONENTS OF PARALLACTIC MOTION

(for $\pi = 0''.01$)

Nova	μ_x	μ_y
Q Cygni	+″.030	—″.001
T Aurigae	+ .005	— .037
Persei (1901)	+ .023	— .035
Geminorum 1	— .006	— .036
Lacertae	+ .034	— .002
Geminorum 2	— .008	— .037

For other values of π multiply the quantities in the table by $\frac{\pi}{.01}$.

These components of the parallactic drift were given in connection with the observed components of proper motion for six of the novae. (See the abstract.)

Of the seven stars in this list we have at present parallax measurements of precision for Nova Persei (1901), Nova Geminorum 2, and Nova Lacertae. For any individual star we may derive its space velocity if we have values for the parallax, proper motion, and radial velocity relative to our sun. It is to be expected that the small values found for proper motion and parallax are subject to a considerable percentage of uncertainty, but as we shall see shortly, in the case of Nova Persei it would seem that the values found for it may be a fair approximation. When we come to the radial motions it is another matter. Radial velocities for several of the novae have been derived from measurement of the sharp absorption lines (Ca & Na) of the spectrum. These values are as a rule, within errors of observation, of the same magniture as the component of solar motion. It seems probable therefore that these so-called radial velocities of novae are not due to their bodily velocity of translation, and it is questionable if it is permissible to use such radial velocities with proper motion and parallax values to determine the space velocity. I have carried through a computation of space velocity for Nova Persei (1901). The components of proper motion relative to the faint comparison stars used in these observations are taken with the same meaning as for standard proper motions determined with the meridian circle.

NOVA PERSEI (1901)

Recent parallax and proper motion data.

Parallax:

$\pi = +0''.009$, absolute parallax by Van Maanen
$\pi = +0''.013$, absolute parallax all determinations reduced by Van Maanen
$\pi = +0''.0093$ Indirect method, by Turner. Observational data: apparent changes in nebulosity near Nova shown on photographs taken several months after the outburst.

Proper motion:

$\mu_x = -0''.009$, $\mu_y = -0''.015$ } Lowell Observatory photographs and Prof. Barnard's earlier observations.

$\mu\ \alpha = -0''.017$ Van Maanen

$\mu\ \alpha = -0''.011$, $\mu\ \delta = -0''.022$ } Reduction of a part of Prof. Barnard's observational data. Editorial note in Monthly Notices, June, 1920.

If we take

$$\pi = +0''.010, \quad \mu_x = -0''.009, \quad \mu_y = -0''.015, \text{ Rad. Vel.} = +5.4 \text{ km/sec}$$

the resulting components of space velocity, referred to equatorial axes, are:

$$v_x = +8.8,\ v_y = -13.1,\ v_z = +8.6, \text{ and } v = 18 \text{ km/sec (approx.)}$$

with the apex of motion in R. A. $20^h\ 15^m$ and Dec. $+28°.5$.

Lowell Observatory,
Flagstaff Arizona, March 1921.

TWENTY-SIXTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The twenty-sixth meeting of the Society was held from August 30 to September 1, 1921, at Wesleyan University, Middletown, Connecticut, on the invitation of Professor Frederick Slocum, director of the Van Vleck Observatory. As in recent summer meetings the members had the privilege of being housed together in college dormitories, and all meals were served in the spacious Psi Upsilon fraternity house. The scientific sessions were held in the John Bell Scott Laboratory, one of the college buildings nearby, and the members thus had once more the pleasure of continuous company, beginning for some with a congenial early plunge in the gymnasium swimming pool, and lasting until a late hour at night.

On the first day the morning and afternoon sessions for papers were carried on according to schedule, and by four o'clock the members were ready for the first excursion. The most vigorous if not the youngest group went for a "hike" planned by Dr. William North Rice, emeritus professor of geology at Wesleyan, and led by Professor W. C. Woods of the biology department. Through the courtesy of residents of Middletown the others were taken in automobiles for a

trip under the leadership of Dean F. W. Nicholson. Each car followed the one ahead and for a time all went smoothly, but before long those in the second half of the procession found that they had been trailing an outsider who turned off on a by-road quite unconscious of the havoc he had wrought in the arrangements. Another leader was chosen by the survivors, but it was not long before it seemed to be every driver for himself. In a general way the route was from Middletown to Hartford to Meriden to Middletown, but it will never be known just what variations were made by the different cars. However, any ride in this part of the country is attractive, and all voted the excursion a success.

While on the subject of motor cars it may be noted that at each successive meeting of the Society there are more and more members who come by automobile, and it will not be long until, for a New England meeting at least, a road map will be more useful than a railway time table.

On the first evening the visitors were hospitably received by Mr. and Mrs. Slocum at the Van Vleck Observatory which was thrown open for inspection. It was a revelation to some of us who think we know about observatories to find what a really modern astronomical building is like, and to note the various arrangements for the convenience and comfort of the observers. As is well known, the completion of the objective of the twenty-inch refractor was delayed by the war, but the glass disks are now in the hands of the opticians, and it is expected that the splendid equipment of mounting, rising floor, and dome will soon be used to the utmost.

On the second day there were two more sessions for papers followed by another excursion, this time a boat ride on the Connecticut River. Three vessels were placed at our disposal, one under the able command of a member of the Society who had sailed in from a distant port. The breezes from over the water were a relief from the heated intellectual atmosphere of the lecture room, and those who were first back to supper voted the trip a grand success. However it soon developed that there were many vacant places, and a count disclosed that fully half of the usual number were missing. A hurried investigation showed that one boat had not returned, and there was an anxious hour for those on shore, until it was found that nothing more serious than a shortage of gasoline had caused the delay, and the extra wait had only whetted the appetites and increased the good humor of the castaways.

The evening of this day had been left open on the program, but it had been agreed to have fuller discussions of some of the topics which had been brought up by papers at the regular sessions. In particular there were two round-table groups which debated at some length on the reality of certain minute observed variations, and as it happened the subjects were in two contrasted fields of astronomy; one the diurnal variation of clock rates, and the other, secondary

fluctuations in short-period variable stars. There was another table nearby which was also round, but where there were only four in the discussion. Still another astronomical pursuit was carried on in a room from which all tables, round or otherwise, had been cleared.

On the third day, the papers were varied by the election of officers and the reading of committee reports. The formal program was completed early in the afternoon. After this the members and friends were delightfully entertained at tea by President and Mrs. Shanklin at their home on the campus.

The final event of the meeting was the evening conversazione for which had been reserved some of the illustrated papers, also individual exhibits of different members.

Various actions which were taken by the Council are of interest to the Society as a whole. On due nomination by members the Council elected to honarary membership:

Professor CARL WILHELM LUDVIG CHARLIER, University of Lund.

In the past, the Society has had different standing committees, some of them still quite active and others whose work has been completed. On recommendation of a special sub-committee, Messrs. Klotz and Bailey, the Council took the following general action to take effect at the annual meeting of 1922.

1. The abolition of such committees whose functions are carried out by other organizations: e. g., Committee on Variable Stars, Committee on Photographic Astrometry, Committee on the Teaching of Astronomy.

2. The functions of committees now in existence shall be considered terminated.

3. Each committee appointed hereafter shall report to the Society on or before the next following annual meeting, when the functions of the committee shall cease, unless renewed by request of its chairman for completing its work in the succeeding year.

4. At the annual meeting of the Society, the Council shall appoint such committees as may be necessary to further the work of the Society.

New officers were elected as follows:

Vice-President	1921-1923	John A. Miller
Secretary	1921-1922	Joel Stebbins
Treasurer	1921-1922	Benjamin Boss
Councilors	1921-1923	Philip Fox
	1921-1924	A. O. Leuschner
	1921-1924	Frederick Slocum

Officers continuing to serve are:

President	1919-1922	Frank Schlesinger
Vice-President	1920-1922	Otto Klotz
Councilors	1919-1922	Henry Norris Russell
	1919-1922	V. M. Slipher
	1920-1923	Caroline E. Furness

Professor E. B. Frost was elected as a representative of the Society

on the Division of Physical Sciences of the National Research Council for the term 1922-1925.

The nominating Committee for the election of officers in 1922, which will include a new president, has been appointed and consists of Messrs. E. S. King, *Chairman;* W. T. Olcott, and Miss Harriet W. Bigelow. Any member is welcome to send suggestions to this committee.

New members of the Society including those elected by mail vote of the Council during the year, were as follows:

Harold D. Babcock, Mount Wilson Observatory, Pasadena, Cal.
Victor Hugo Benioff, Mount Wilson Observatory, Pasadena, Cal.
Mildred Booth, Yale Observatory, New Haven, Conn.
Ada M. Brayton, Mount Wilson Observatory, Pasadena, Cal.
Keivin Burns, Allegheny Observatory, Pittsburgh, Pa.
Edwin F. Carpenter, Students' Astronomical Laboratory, Cambridge, Mass.
Willard Peabody Gerrish, Harvard College Observatory, Cambridge, Mass.
Herbert E. Ives, Western Electric Company, New York.
Maynard F. Jordan, Students' Astronomical Laboratory, Cambridge, Mass.
Mary C. Joyner, Mount Wilson Observatory, Pasadena, Cal.
Lois M. Keener, Mount Wilson Observatory, Pasadena, Cal.
Florence MacCreadie, Mount Wilson Observatory, Pasadena, Cal.
Mrs. H. M. Marsh, Mount Wilson Observatory, Pasadena, Cal.
John Millis, Fort Sheridan, Ill.
Carlos S. Mundt, Concord, Cal.
Gilbert Thomas Rude, U. S. Coast and Geodetic Survey, Washington, D. C.
Bertha M. Shumway, Mount Wilson Observatory, Pasadena, Cal.
Carroll Mason Sparrow, University, Virginia.
Louise W. Ware, Mount Wilson Observatory, Pasadena, Cal.

This brings the total membership up to 369.

The attendance at the meeting was once more the largest in the history of the Society, about eighty members being present, and the guests brought the total to well over one hundred. The members present were:

Sebastian Albrecht
Leah B. Allen
Weld Arnold
S. I. Bailey
Ida Barney
S. G. Barton
L. A. Bauer
Louis Bell
Harriet W. Bigelow
Mildred Booth
Benjamin Boss
E. W. Brown
Annie J. Cannon
E. F. Carpenter
J. L. Coolidge
C. R. Cross
C. H. Currier
H. D. Curtis
R. E. De Lury
Louis Derr
W. S. Eichelberger
Alice H. Farnsworth
Jennie V. France
Edgar Frisby
Caroline E. Furness
N. E. Gilbert
A. Estelle Glancy
C. C. Godfrey
W. K. Green
Vera M. Gushee
Margaret Harwood
M. Alberta Hawes
F. Henroteau
C. S. Howe
W. R. Jewell
M. F. Jordan
C. E. Kelley
E. S. King
Otto Klotz
Eleanor A. Lamson
F. B. Littell
Guy Lowell
C. A. R. Lundin
E. S. Manson, Jr.
Antonia C. Maury
J. A. Miller
W. I. Milham
Margaretta Palmer
Jesse Pawling
G. H. Peters
J. H. Pitman
I. M. Poor
W. T. Olcott
A. W. Quimby

Harry Raymond	Frederick Slocum	F. D. Urie
Susan Raymond	C. L. Stearns	F. W. Very
E. D. Roe, Jr.	Joel Stebbins	W. R. Warner
F. E. Ross	H. T. Stetson	Sarah F. Whiting
A. J. Roy	Helen M. Swartz	Evelyn W. Wickham
R. F. Sanford	John Tatlock	R. E. Wilson
Frank Schlesinger	R. H. Tucker	Jessica M. Young
Harlow Shapley	A. B. Turner	

On the last day the following resolutions, introduced by Dr. Klotz were adopted:

> *Resolved*, That the American Astronomical Society herewith places on record its appreciation of the invitation extended by the President and Trustees of Wesleyan University to the Society for holding its annual meeting at Middletown, where the accommodation in every respect and for every want was so ample and commodious, leaving nothing to be desired.
>
> To Professor and Mrs. Slocum and their able assistants, the Society expresses its gratitude for the assiduity and solicitude shown in making the whole stay at Wesleyan University such a memorable success.

In view of the increasing interest taken in the gatherings of the Society, the Council felt that the time has come when one meeting per year is not sufficient, and it has agreed to make a trial for the coming year of having two meetings, one in Christmas week in 1921, and the annual meeting in the summer of 1922, the two gatherings to be widely separated geographically. The definite decision and details were left as heretofore with the president and secretary.

REPORTS OF COMMITTEES.

REPORT OF THE ECLIPSE COMMITTEE.

By W. W. Campbell, *Chairman.*

The total solar eclipse of September 21, 1922, will be observable at the following principal points, subject to weather and other conditions as stated:

1. *Maldive Islands*, Indian Ocean. Longitude 73° E, latitude 3° N. Duration of total phase $4^m\ 10^s$. Local true time $8^h\ 16^m$ A. M. True sun's altitude 34°. The Maldives are composed of several hundred low tropical islands, and observing stations would be practically at sea level. Mr. Hinks, secretary of the Royal Geographical Society, quotes the meteorlogists as saying that the monsoon (rainy season) is normally over in early September, that the chances for clear sky are good, and that the prevailing winds are rather heavy. There appear to be no scheduled steamers running to the Maldive Islands. This location is not attractive to American observers.

2. *Christmas Island*, Indian Ocean. Approximately 200 miles directly south of the extreme west end of Java. Longitude 105° 40′ E, latitude 10° 25′ S. The eclipse will occur at local true time about $11^h\ 50^m$ A. M., with the sun 12° north of the zenith. Duration approximately $3^m\ 40^s$. The island is roughly 8 miles wide north and south,

and 10 miles long east and west. It lies only a few miles within the northern boundary of the shadow path. The southwesterly point of the island is in approximate longitude 105° 35′ E and latitude 10° 30′ S, and about 50 statute miles from the central line of the shadow. The harbor is on the north side of the island and a railway runs to the south side. The climate is tropical. The average annual rainfall is 72 inches, most of this occurring in the months December to May. The southeast trade wind is said to blow almost uninterruptedly from May to December. The maximum and minimum temperature readings indicate comfortable conditions. The rainfall in September is said to be slight, with average cloudiness 30 per cent., though the Government Meteorologist of Australia is responsible for the statement that heavy September falls, ranging up to 14 inches in 1909, and October falls, up to 23 inches in 1910, with a fall of 6.5 inches in 24 hours in September, 1909, have occurred. Steamers belonging to the Phosphate Company which operates on the island are reported to run once per month from Singapore. Intending eclipse observers must make all arrangements for an observing station and for transportation with the operating company. The British Joint Eclipse Committee will send an expedition to the island; the observers will arrive several months in advance of the eclipse date, to obtain night photographs of the sky needed in connection with the Einstein problem. It is not known that any American observers are planning to observe the eclipse from Christmas Island.

3. *Ninety Mile Beach*, north-west Australia. The central line of the shadow path enters the continent of Australia at the combined telegraph and post station of Wollal, longitude 120° 41′ E, latitude 19° 44′ S. Duration 5^m 18^s. Local true time 1^h 40^m P. M. Sun's altitude 58°. This region of Australia is excessively dry. The average rainfall for August, September and October does not exceed 0.06 inches monthly. The rain falls mostly from December to March inclusive. The percentage of cloudiness is said to be very low and the winds light. Rainfall in total amount greater than 0.1 inch has been recorded in only two Septembers in 23 years, and in only one October in 23 years. It seems clear that an observing station at Wollal would have decided advantages as to weather conditions and duration of totality over any other station.

It has been proposed to the Government authorities of Australia that naval or other official transport for eclipse parties from Perth or Broome to Wollal and return would be ideal and be fully appreciated by the observers. The responsible authorities have not rendered their decision for or against. It appears entirely practicable to reach Wollal by the following methods: steamers of the Northwest Coast and Singapore Line sailing fortnightly from Perth to Broome. Broome is a village of 3,000 people more or less, situated approximately 200 miles NNE from Wollal. Transport of observers, instruments and supplies by schooner or launch from Broome to the beach opposite

Wollal, at prices quite reasonable. Landing one mile from the Wollal telegraph station either by beaching the boat with the tide or by surf boat is reported by reliable authorities to be entirely dependable. The telegraph operator who has lived at Wollal many years, nautical officials residing at Broome, and Australian officials elsewhere are in agreement on these points. Packages should not exceed 200 or 300 pounds in weight. A fair road leads from the beach to the telegraph and post station. A sheep ranch is located three miles southerly from the post office. There is a Government well 150 yards from the post office, with good water in abundance, and trees in whose midst camp could be established. Fuel is plentiful. Natives are available to assist in rough work. There are no mechanics in the vicinity. All supplies and expert labor should be brought from Perth and Broome, though fresh mutton in case of need can be secured at the ranch. The country back of the telegraph station is desert, practically level, with stunted vegetable growth.

The Lick Observatory definitely plans to dispatch a modest expedition to Wollal. The principal observations on the program relate to the Einstein problem. On account of the difficulties of transport to and from Wollal, and the discomforts of long residence at Wollal, it is planned that the night photographs of the eclipse group of stars shall be secured en route at Tahiti in June, 1922, with the cameras adjusted as closely as possible to the conditions which are expected to prevail at Wollal in September. The latitudes of Tahiti and Wollal are nearly the same. In addition to the critical eclipse field of stars it is intended to photograph another selected night group of stars at both Tahiti and Wollal.

4. *Coongoola*, southern Queensland. Longitude 146° 0′ E, latitude 27° 45′ S. Duration 3^m 45^s. Local true time 4^h 1^m P. M. Sun's altitude 26°. Railway service from Brisbane twice per week. Coongoola consists of a small galvanized iron railway station and a galvanized iron hotel. The surrounding country is flat and pretty barren. The prospects for clear sky are good. The average rainfall in September has varied from zero to a maximum of 6.1 inches. Observers must expect many discomforts, including dust storms, and the conditions following a rain are exceedingly disagreeable as to mud. The committee is unable to encourage the establishing of an observing station in this vicinity, and further is of the opinion that the conditions existing between Wollal and Coongoola are so inhospitable as to travel and living that no effort should be made to locate an observing station in that long section of the shadow path.

5. *Goondiwindi*, southern Queensland. Longitude 150° 20′ E, latitude 28° 30′ S. Duration 3^m 30^s. Local true time 4^h 21^m P. M. Sun's altitude 21°. Conditions are favorable as to clear sky, but dust storms must be expected. The average monthly rainfall has varied from zero to 4.4 inches. One train per week from Brisbane reaches Goondiwindi.

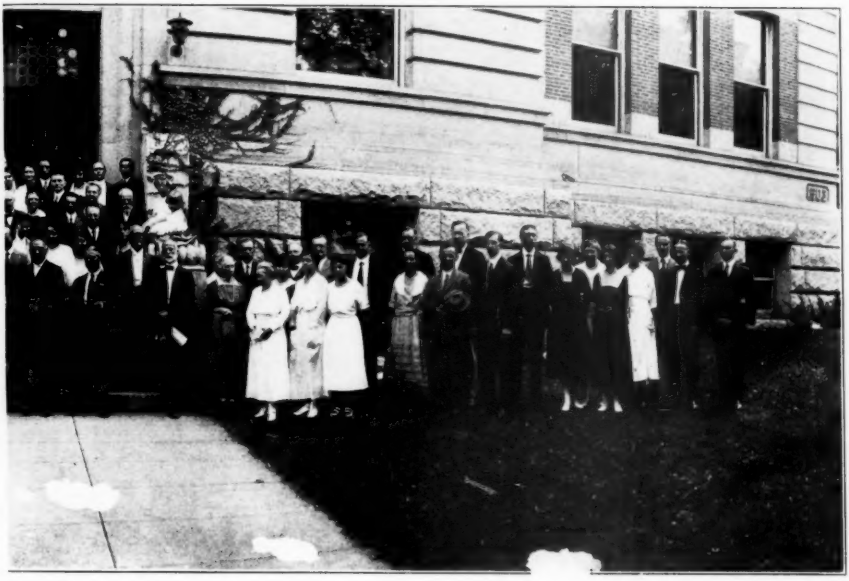
PLATE XXIV

MIDDLETOWN MEETING OF THE

KEY TO PLATE XXIV

1 Pitman	13 Miss Palmer	24 Barton	36 Milham
2 R. E. Wilson	14 Bell	25 Miss Gushee	37 Cross
3 Mrs. Roy	15 J. M. Poor	26 Albrecht	38 Jewell
4 Roy	16 Lundin	27 Littell	39 Miss Cannon
5 Miss Frisby	17 Peters	28 King	40 Miss Barney
6 Very	18 Roe	29 Curry	41 Miss Whiting
7 H. D. Curtis	19 Slocum	30 Miss Wickham	42 J. A. Miller
8 Tatlock	20 Sebastian Albrecht,	31 Raymond	43 Klotz
9 Miss Furness	Jr.	32 Derr	44 Miss Bigelow
10 Warner	21 Pawling	33 Miss Harwood	45 Miss Jessica Young
11 Miss Lamson	22 Eichelberger	34 Mrs. Roe	46 Quimby
12 Stebbins	23 Kelley	35 E. W. Brown	47 Shapley

PLATE XXIV (Continued)



AMERICAN ASTRONOMICAL SOCIETY

KEY TO PLATE XXIV (Continued)

48 Bauer
49 Miss Farnsworth
50 Mrs. Quimby
51 Schlesinger
52 Carpenter
53 Henroteau
54 Miss Hawes
55 Olcott
56 Miss Raymond
57 Miss Fuller
58 Boss
59 Urie
60 Mrs. Young
61 De Lury
62 Arnold
63 Frisby
64 Mrs. Urie
65 Godfrey
66 Naomi Albrecht
67 Ruth Urie
68 Bailey
69 Miss Jane Van Vleck
70 Miss Clara Van Vleck
71 Lowell
72 Mrs. Slocum
73 Miss France
74 Coolidge
75 Mrs. Stetson
76 Manson
77 Miss Harding
78 Sanford
79 Green
80 Miss Maury
81 Ross
82 A. B. Turner
83 Stetson
84 Tucker
85 Mrs. Gilmore
86 Miss Swartz
87 Miss Allen
88 Miss Booth
89 Read
90 Stearns
91 M. F. Jordan

Observers can live in fair comfort and obtain supplies and assistance in limited variety.

6. *Stanthorpe,* southern Queensland. Longitude 152° 0′ E, latitude 28° 40′ S. Duration 3^m 25^s. Local true time 4^h 30^m P. M. Sun's altitude 19°. Average cloudiness in September 30 per cent. Average rainfall in September 2.5 inches, varying from zero to 9.3 inches. Mean maximum September temperature 67° F, mean minimum 41° F. Altitude of railway station 2,600 feet. The neighborhood is hilly, and there are rock outcroppings, but here as elsewhere dust storms must be expected. The west wind is said to be worst in July and August (midwinter), when it sometimes blows persistently for several days with the force of a gale, and is bitterly cold. These conditions, modified, can reasonably be expected to occur during the period of eclipse preparations. Stanthorpe is a favorite *summer* resort for Queenslanders and there are good hotels. Supplies and labor can either be supplied locally or obtained from Brisbane and Sydney. Railway service is good.

7. *Casino,* southern Queensland. Longitude 153° 0′ E, latitude 28° 50′ S. Duration 3^m 20^s. Local true time 4^h 34^m P. M. Sun's altitude 18°. Average September rainfall 2.1 inches, varying from zero to 5.8 inches. The altitude of Casino is not so great as that of Stanthrope, and greater comfort of observers would be promised, but the low altitude of the sun should be held in mind. Casino is not on a main line railway, but access is fairly easy. The region is a favorite one for summer tourists. The committee is unable to recommend that technical observers of the eclipse seriously consider a location in this region.

There are many established steamer lines available for transport to and from Australia, and observers will have no difficulty in selecting the route which best conforms to their requirements.

The total solar eclipse of September 10, 1923, will be observable under very promising conditions from the vicinity of San Diego, California, from the large islands lying southerly from Santa Barbara and westerly from San Diego, from Lower California, and from the interior of western Mexico. San Diego is well within the shadow path and the central line of the shadow crosses the island of San Clemente. San Nicholas Island is a few miles south-west of the central line and San Miguel Island and Santa Rosa Island a few miles north-east of the central line. The central line enters Lower California in Todos Santos Bay, near Ensenada, and passes east-southeasterly across Mexico, intersecting the shore of the Gulf of Mexico a short distance south of Tampico. The weather conditions in the San Diego, Ensenada and the islands regions are almost certain to be good in early September, though coast fogs may be an obstacle, and the eclipse hour, 1 P. M., is favorable. The Mexican Weather Service has undertaken to secure observations of weather and sky conditions

at the hour of the day that the eclipse will occur at each of several Mexican stations, throughout the first half of September this year and next, in continuation of similar series of observations last year. The chairman of this committee will visit the eclipse path in Lower California and probably a few other points near the center of the shadow zone in early September of this year, in order to estimate the probable conditions of atmosphere, subsistence, labor, etc., which may be expected to prevail at the same season of the year two years hence. It is planned to prepare a report on all points of interest to prospective observers for issue about the first of next year.

The high altitude of the sun and the fairly long duration, more than three and a half minutes, should tempt a goodly number of experienced observers to establish their observing stations in places conveniently reached from the south-western part of the United States.

REPORT OF THE COMMITTEE ON VARIABLE STARS.

By Leon Campbell, *Chairman.*

Acting on the endorsement of the Society at its Northampton meeting of the plan to obtain data concerning variable star work and telescopes in this country, a circular letter, with a suitable blank enclosed, was sent to some 350 individuals and institutions.

Replies were received from nearly one hundred and the results are worth mentioning in detail. These replies came from thirty-sever observatories and professional astronomers, and from fifty-three amateurs. Photometric work is being carried on at five observatories and two others are proposing to do so. Photographic investigations are under way at eight observatories and are contemplated by two experienced amateurs. Eight professionals and thirty-eight amateurs are devoting their main energies to direct visual estimates, principally of the long period and irregular variables.

Seventeen institutions possessing instrumental equipment are *not* doing any variable star work.

Novae are being followed by nineteen observers; stars of long period by forty-six; irregulars, by thirty-seven; Cepheid and eclipsing stars, by seven more.

On the whole, this indicates considerable activity in the variable star field. Yet the efforts of the individuals do not appear to be coördinated, except possibly on the long period variables. If some arrangements could be made whereby observers would be kept informed of the working program of the other observers, a great gain would doubtless be made in efficiency.

The publication of ephemerides, especially of the eclipsing variables, with accurate times of minima, seems very desirable. A case in point is that of β Persei, where no two of the ephemerides published

agree within a half hour. Professor Stebbins' publication of the correct observed time of a minimum in October, 1920, has been most helpful in predicting minima for 1921-1922. Similar corrections to ephemerides would be most useful.

The annual prediction of maxima and minima of long period variables by Harvard keeps one closely informed of the most probable dates of these phases.

Ninety-two telescopes were reported as being used for astronomical work, of which sixty are being devoted, in part at least, to variable star investigations. Eighteen instruments have been reported as idle, except for occasional sight seeing purposes.

Telescopes would be loaned by five individuals, and twenty institutions and individuals would permit the use of their instruments by competent observers, these in most instances being institutions possessing idle telecopes.

This shows a commendable spirit on the part of such institutions and it is to be hoped that due advantage may be taken of these offers.

Through this canvass, the names of thirty-three owners of telescopes were brought to the attention of the committee, and it may be that some of these can be induced to take up some phase of variable star work.

REPORT OF THE COMMITTEE ON METEORS.

By Chas. P. Olivier, *Chairman.*

During the past year there has been no work nor problems in meteoric astronomy that called for the attention of the committee as a whole. The chairman has however kept in close touch with the committee of the International Astronomical Union and some progress toward unification of aims and methods is being made.

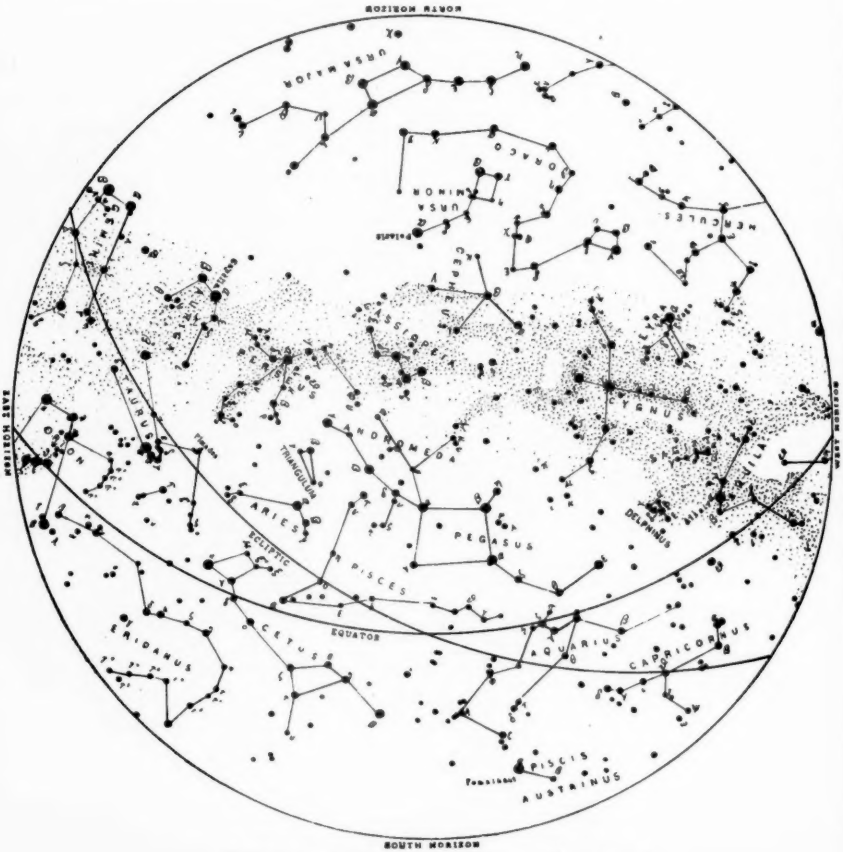
The American Meteor Society continues its work along former lines, more observing having been done this year than the former one. At the McCormick Observatory some fairly promising experiments are being made in photographing meteors. At the Perseid maximum of August, 1921, considerable data were secured for computing real heights of meteors from visual observations. Washington, D. C., was the other station used. The complete report of the work of the American Meteor Society for the years 1914 to 1918 inclusive has appeared as Vol. II, Part 7, *Publications of the Leander McCormick Observatory.*

PLANET NOTES FOR NOVEMBER.

(The times given are Central Standard unless otherwise stated)
The moon's phases will be as follows:

	h m
First Quarter	Nov. 7 9 53.8 A. M.
Full Moon	Nov. 15 7 39.1 A. M.
Last Quarter	Nov. 22 5 41.0 A. M.
New Moon	Nov. 29 7 25.7 A. M.

Mercury will not be very well placed for observation this month. While it reaches greatest western elongation on the 16th, still it will be only 19° from



THE CONSTELLATIONS AT 9:00 P. M. NOVEMBER 1

the sun at that time. With a very clear horizon it may be possible to see the planet for a short time before sunrise about the middle of the month.

Venus will be a morning star throughout the month. It will be a conspicuous object even though gradually approaching the sun. In the telescope it will appear nearly round, as it is in that part of its orbit beyond the sun.

Mars will be a morning star, about 3 hours west of the sun on the 15th. As an object for observation it will not be very satisfactory, as it reaches aphelion on the 3rd, at which time its apparent diameter will be only a little over four seconds of arc and its distance from the earth will be over 200 million miles.

Jupiter and *Saturn* will be close together in the constellation Virgo and about 3 hours from the sun on the 15th. The planets will thus be in fair position for observation shortly before sunrise.

Uranus will be in Aquarius throughout the month and in good position for early evening observation. The planet will appear in quadrature on the 28th.

Neptune remains in Cancer and will reach quadrature on the 8th.

The planets, as will be noted, are all morning stars with the exception of Uranus. It would be of some little interest to see if it will be possible to see all these planets within a few minutes of each other at the time Mercury reaches western elongation about the middle of the month.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1921	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Nov. 12	88 Piscium	6.2	4 47	76	5 52	239	1 05
17	124 H^1 Orionis	5.7	18 15	97	19 18	281	1 03
19	30 B Cancri	6.1	17 24	56	18 10	342	0 46
20	α Cancri	4.3	11 38	111	12 39	271	1 01
24	319 Virginis	6.3	18 02	142	19 10	271	1 08

VARIABLE STARS.

New Variable BD+51°2742=6.1921 Cygni.—This is announced by G. E. H. Haarh, of Copenhagen, in *Astronomische Nachrichten* No. 5117. It is a short period variable, ranging between magnitudes about 8.4 and 9.1, in a period of 6.35 days. The elements given are

$$\begin{aligned} \text{Maximum} &= \text{J. D. } 2422645.3 + 6.35\,E \\ \text{Minimum} &= \qquad 2422731.2 + 6.35\,E. \end{aligned}$$

(d)

This star was used as one of the comparison stars for Nova Cygni 1920, and its variation was found in connection with the study of the fluctuations of the Nova. The position for 1855 is

$$\alpha\,(1855) = 19^h\ 57^m\ 35^s.2, \qquad \delta\,(1855) = +51^\circ\ 41'.1.$$

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921 November							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8					3 19			
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	4 10	12 2	19 18	27 11				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	6 21	14 8	21 18	29 4				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	8 4	15 15	23 3	30 14				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	8 21	15 0	21 3	27 5				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	3 7	10 10	17 4	24 17				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 15	13 12	20 9	27 6				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 19	14 23	23 3	29 7				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2		9 9	18 4	26 23				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 10	14 18	22 8	30 6				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6		10 18						
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 11	10 4	15 22	27 9				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	5 20	12 15	19 10	26 6				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	7 1	14 23	22 20	30 18				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	5 6	13 14	21 21	30 4				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4		8 20	16 18	24 15				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	7 1		20 6					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	2 12	11 23	21 9	30 20				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		8 17		21 3				
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	3 11	10 3	16 19	30 2				
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	5 12	13 17	21 21	30 1				
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	1 21	7 21	13 22	19 22				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0		5 19	14 11	23 3				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9		6 6	16 16	27 1				
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 1	12 1	20 2	28 2				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 5	16 16	22 10	28 3				
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	9 20	15 10	21 0	26 15				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	4 2	12 7	20 11	28 16				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7		8 10	16 0	23 16				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	5 20	18 0	30 5					
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	5 12	12 16	19 20	27 1				
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	9 0	15 20	22 15	29 11				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2		6 9	15 17	24 23				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2 19	9 10	16 0	22 15				
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	4 10	12 20	21 5	29 15				
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	7 16	14 2	20 12	26 23				
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	5 0	12 7	19 13	26 20				
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	8 20	16 23	25 2					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	1 9	10 20	20 8	29 17				
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	1 15	8 11	15 7	22 4				
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	1 21	7 20	19 17	25 15				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	4 1	10 19	17 13	24 7				
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	4 20	12 6	19 16	27 3				
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	5 23	12 13	19 4	25 18				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4 15	13 10	22 5					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1 7	9 6	16 14	23 22				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 2	9 21	16 15	23 10				
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	6 6	13 19	21 7	28 19				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1		9 1	18 16	28 6				
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	2 5	9 16	17 2	24 13				
133026 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	8 22	14 17	20 12	26 7				

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921 November					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	4 23	11 12	18 22	25 21		
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	2 12	9 10	16 7	23 5		
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.3	4 9	12 19	21 5	29 16		
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	6 3	13 19	21 10	29 2		
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	5 5	12 13	19 21	27 5		
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	6 12	14 18	23 0			
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	5 8	14 5	23 1			
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	6 3	15 20	26 21			
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	4 10	11 5	18 1	24 20		
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	7 17	16 2	24 12			
μ Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 2	7 6	13 9	19 13		
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	6 11	12 16	18 20	25 0		
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	7 21	15 6	22 15	30 0		
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6		8 22	17 2	25 6		
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	1 10	8 23	16 12	24 1		
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 21	12 15	20 9	28 3		
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	6 9	14 9	22 8	30 8		
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	3 3	11 15	20 4	28 16		
WY Sagittarii	17 54.9	—23 1	9.5—10.6	4 16.0	7 9	16 17	26 1			
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1		10 19	21 3			
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	5 18	13 0	20 5	27 11		
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	7 14	14 12	21 9	28 7		
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	4 17		19 20			
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	3 12	10 16	17 20	25 0		
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	3 0	10 3	17 5	24 8		
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	5 11	13 19	22 2	30 9		
RR Draconis	40.8	+62 34	9.3—13	2 19.9	3 10	11 22	20 10	28 21		
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	3 23	10 15	23 23	30 13		
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	5 16		18 13			
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	1 9	9 1	16 16	24 8		
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	2 10	9 23	17 13	25 3		
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	7 19	13 9	20 14	27 18		
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	3 2	12 1	20 0	28 23		
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	5 3	11 22	18 16	25 10		
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7 10	14 19	22 3	29 12		
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	5 22	16 10	21 16	26 21		
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3 1	9 13	16 2	22 14		
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	5 16	11 16	17 16	23 16		
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 7	8 23	15 14	28 21		
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 11	10 14	19 18	28 21		
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 4	14 14	23 1			
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	7 19	14 13	21 8	28 3		
UW Cygni	19.6	+42 55	10.5—13	3 10.8	2 1	8 22	15 20	22 18		
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0				30 16		
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	10 7	19 22	29 13			
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	4 21	14 2	23 6			
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	4 23	12 11	19 23	27 11		
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	7 14	15 4	22 18	31 9		
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	10 11	20 13	30 16			
VVCygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 13	14 22	22 8	29 17		
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	8 10	18 3	27 19			
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	3 22	11 19	19 16	27 13		
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	1 14	11 18	21 21			
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3		12 7				
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	3 3	13 12	18 17	23 21		
8.1914 Pegasi	51.7	+32 41	10.0—10.6	5 06.4	5 5	10 11	15 18	20 23		
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	3 8	11 15	21 22	28 5		
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	4 16	12 5	19 18	27 7		
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	4 14	12 20	21 2	29 8		

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921 November							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	1 4							
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	4 22	13 2	21 5	29 8				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 15	11 9	18 3	26 21				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	3 7		18 3					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3 7	11 5	19 4	27 2				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 21	11 16	19 11	27 6				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	6 9	13 16	20 23	28 6				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		15 0						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0		8 4	16 18	25 7				
SV Persei	42.8	+42 07	8.8— 9.6	11 03 1		11 20		22 9				
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0		6 23	18 14	30 5				
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	6 8	13 23	21 15	29 7				
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3		9 7	19 10	29 13				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 13	14 6	21 24	29 17				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2 18	13 19	24 21	30 9				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	2 4	9 17	17 7	24 20				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		10 16						
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	2 16	10 4	17 14	25 1				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	4 13	11 18	18 23	26 4				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	1 3	9 1	16 23	24 21				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 19	13 23	24 3					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		15 8						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 3	11 2	19 1	26 23				
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	6 16	13 8	20 1	26 17				
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3		8 5	17 12	26 18				
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9		8 22	17 16	26 9				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0			23 0					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	0 15	7 10	14 5	20 23				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 5	11 20	18 10	25 1				
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	2 5	11 21	21 12					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	5 8	13 8	21 7	29 6				
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	5 6	11 23	18 17	25 11				
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	1 19	7 15	13 10	25 2				
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	5 18	10 10	19 19	24 12				
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5		7 20		25 2				
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	1 19	10 0	18 5	26 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 17	13 18	20 18	27 19				
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	2 4	10 9	18 14	26 19				
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	3 5	8 17	19 17	25 5				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 20	10 10	17 23	25 12				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	1 18	9 4	16 14	24 0				
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	6 1	12 20	19 15	26 10				
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	2 20	15 12	21 19	28 3				
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	3 6	13 0	22 18					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	3 4	12 0	20 21	29 18				
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	3 20	9 21	15 23	28 2				
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	5 9	12 10	19 10	26 10				
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9		13 4		30 7				
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	3 22	11 12	19 3	26 17				
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	3 20	9 14	15 9	26 22				
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	7 18	14 11	21 5	27 23				
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	7 10	17 18		28 3				
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	5 1	11 1	17 2	29 4				
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	2 12	8 15	14 18	20 21				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921 November							
	h m	° ′		d h	d	h	d	h	d	h	d	h
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	4	17	10	16	16	15	28	12
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2			8	16	17	18	26	20
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	1	23	9	0	16	1	23	1
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	1	17	8	17	15	17	29	16
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5			8	5	16	5	24	4
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7	14	15	7	22	23	30	16
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	7	3	14	7	21	11	28	15
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	3	8	11	17	20	2	28	11
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5	12	9	20	18	4	24	11
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3			10	2			26	11
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1	22	10	19	19	15	28	12
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	4	23	11	17	18	10	25	4
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	6	13	13	6	19	23	26	16
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4			12	23			27	16
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	2	7	10	4	18	0	25	21
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	6	8	13	5	20	3	27	0
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	1	20	6	16	16	10	26	3
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	2	13	11	5	19	21	28	12
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	9	12	14	21	25	14	30	23
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	7	12	18	10			29	7
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	4	2	10	12	16	22	29	18
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	1	15	6	14	16	14	26	13
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	6	21	17	18	23	5	28	16
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4	23	15	20	21	7	26	17
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5	18	18	9	24	16	30	23
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	7	3			18	6		
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	3	11	10	10	17	10	24	9

Monthly Report of the American Association of Variable Star Observers, June 20 to August 20, 1921.

The Spring meeting of the Association was held at the Vassar College Observatory on May 28. It was attended by a very representative gathering, and Miss Furness, as hostess, deserves great credit for the complete arrangements which had been made for the entertainment and comfort of the members.

At the Council meeting Mr. C. W. Elmer and Mr. J. E. G. Yalden were elected Patrons of the Association. The Association voted to establish a Circulating Library, and named Messrs. McAteer, Waldo, and Yalden a Committee to plan a program of procedure and to edit a catalogue. Mr. McAteer was named Librarian.

Two more bars were added to the Nova Medal presented to Miss Woods last year, making five bars which she has to her credit for the discovery of novae from the photographs.

A special vote of appreciation was extended to Mr. H. O. Eaton in recognition of his faithful services as Recording Secretary during the past year and more.

Timely papers on the variability of the Sun and stars were read by Miss Cannon, Miss Furness and the President.

The banquet held Saturday evening was a most enjoyable affair and President MacCracken and other invited guests from Vassar College added to the pleasure. Mr. Pickering acted as Toastmaster with his usual gift at repartee.

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001046 X ANDROMEDAE—												
	2871.8	<12.5	M,	2878.8	<13.0	Wf,	2884.8	<13.0	Wf,	2895.8	<13.0	Wf,
	2898.7	<12.5	M,	2902.8	<13.0	Wf,	2910.8	<13.0	Wf.			
001620 T CETI—												
	2884.6	6.5	L,	2900.6	6.3	L.						
001755 T CASSIOPEIAE—												
	2848.6	8.8	Gi,	2854.5	8.8	Gi,	2862.6	9.0	Gi,	2866.5	9.4	L,
	2871.8	9.4	M,	2871.8	10.3	Pt,	2872.5	9.2	Gi,	2880.4	9.5	L,
	2885.6	9.6	Gi,	2894.4	10.6	L,	2898.7	10.3	M,	2899.6	9.8	Gi,
	2902.6	10.1	O,	2905.8	10.5	Pt.						
001726 T ANDROMEDAE—												
	2853.4	<11.0	Ch,	2898.7	<11.8	M.						
001838 R ANDROMEDAE—												
	2853.4	<11.0	Ch,	2898.6	<11.0	Bh,	2898.7	11.4	M.			
001909 S CETI—												
	2853.4	<11.0	Ch,	2870.6	<11.2	L,	2878.8	<10.9	M,	2884.6	14.0	L,
	2906.8	<11.8	M.									
003179 Y CEPHEI—												
	2878.8	11.0	M,	2906.8	<11.8	M.						
004047 U CASSIOPEIAE—												
	2850.8	<11.7	M,	2871.8	<12.4	M,	2878.8	<12.8	Wf,	2884.8	<12.8	Wf,
	2892.9	<12.8	Wf,	2898.7	<12.5	M,	2902.8	<12.8	Wf,	2910.8	<12.8	Wf.
004132 RW ANDROMEDAE—												
	2884.8	9.6	M,	2902.6	10.2	O,	2902.8	10.3	M,	2910.6	10.5	O.
004435 V..ANDROMEDAE—												
	2902.6	9.7	O,	2905.8	9.6	M,	2910.6	9.7	O.			
004633 RR ANDROMEDAE—												
	2878.8	<12.6	Wf,	2884.9	<12.6	Wf,	2892.9	<12.6	Wf.	2902.9	<12.6	Wf,
	2905.8	<11.2	M,	2910.8	<12.6	Wf.						
004746a RV CASSIOPEIAE—												
	2866.5	<13.0	L,	2880.5	13.8	L.						
004958 W CASSIOPEIAE—												
	2848.6	10.6	Gi,	2862.6	10.8	Gi,	2872.5	11.1	Gi,	2884.8	12.2	M,
	2886.5	11.1	Gi,	2901.5	11.1	Gi,	2910.6	<9.5	Cg.			
010940 U ANDROMEDAE—												
	2871.8	10.3	M,	2886.8	10.2	M,	2906.7	10.5	M.			
011041 UZ ANDROMEDAE—												
	2871.8	10.6	M,	2886.8	10.6	M,	2906.7	10.9	M.			
011272 S CASSIOPEIAE—												
	2867.8	11.4	Wf,	2878.8	12.0	M,	2879.5	10.6	Rk,	2880.8	11.2	Wf,
	2885.9	10.9	Wf,	2886.8	11.3	Pt,	2895.9	10.8	Wf,	2898.8	10.5	M,
	2900.7	10.8	Pt,	2901.4	10.5	Rk,	2902.9	11.1	Wf,	2910.8	10.7	Wf.
011712 U PISCIUM—												
	2910.8	11.4	M.									
012350 RZ PERSEI—												
	2886.8	11.2	M,	2905.8	11.4	M.						
012502 R PISCIUM—												
	2878.8	9.0	M,	2886.8	8.9	Pt,	2898.8	9.2	M,	2905.8	9.6	Pt.
013238 RU ANDROMEDAE—												
	2853.4	<11.0	Ch,	2867.8	11.0	Wf,	2880.9	11.3	Wf,	2884.9	10.5	Wf,
	2895.9	10.3	Wf,	2902.9	10.5	Wf,	2905.8	10.6	M,	2905.8	10.7	Pt,
	2910.8	10.5	Wf.									
013338 Y ANDROMEDAE—												
	2853.4	<11.0	Ch,	2905.8	<11.4	M.						
014958 X CASSIOPEIAE—												
	2878.8	<11.6	M,	2880.8	12.0	M,	2902.8	12.5	M.			
015354 U PERSEI—												
	2878.8	9.3	M,	2882.8	9.1	Pt,	2898.8	9.1	M,	2905.8	9.8	Pt.
021024 R ARIETIS—												
	2858.6	10.0	L,	2867.6	9.9	Gi,	2870.6	10.8	L,	2877.6	11.0	Gi,
	2882.6	11.6	L,	2884.8	<11.1	M,	2887.6	11.7	Gi,	2901.5	12.8	Gi,
	2920.8	11.1	M.									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
021143a W ANDROMEDAE—												
	2857.6	11.7	Gi,	2867.8	11.8	Wf,	2871.5	11.3	Gi,	2880.9	11.3	Wf,
	2882.6	11.0	Gi,	2887.8	10.8	Wf,	2895.9	9.9	Wf,	2897.6	9.5	Gi,
	2902.9	9.4	Wf,	2906.8	8.6	M,	2910.8	8.8	Wf.			
021381 Z CEPHEI—												
	2886.8	11.2	M,	2906.8	11.3	M.						
021403 o CETI—												
	2853.4	4.2	Ch,	2870.6	4.1	L,	2884.6	4.7	L,	2886.8	5.0	Pt,
	2898.8	5.0	M,	2900.6	5.4	L,	2905.8	5.0	Pt.			
021558 S PERSEI—												
	2898.8	8.7	M.									
022150 RR PERSEI—												
	2898.8<11.6 M.											
022813 U CETI—												
	2886.8	7.5	Pt,	2905.8	7.2	Pt.						
02[illegible] RR CEPHEI—												
	2821.4	9.9	L,	2843.6	9.9	L,	2862.4	9.8	L,	2866.7	10.1	Wf,
	2871.4	10.6	L,	2879.9	10.6	Wf,	2880.5	10.7	L,	2884.9	10.6	Wf,
	2886.6	11.1	L,	2886.8	11.0	M,	2897.9	11.7	Wf,	2901.4	11.6	L,
	2902.9	11.8	Wf,	2906.8	11.5	M,	2910.8	11.7	Wf.			
023133 R TRIANGULI—												
	2882.8	9.1	Pt,	2884.8	9.2	M,	2898.8	9.9	M,	2905.8	10.1	Pt.
024356 W PERSEI—												
	2882.8	10.5	Pt,	2884.8	10.5	M,	2898.8	10.4	M,	2902.6	10.2	O.
	2905.7	10.3	Ps,	2905.8	10.5	Pt,	2906.7	10.1	Ca.			
030514 U ARIETIS—												
	2885.6	10.2	Gi,	2901.6	11.6	Gi.						
031401 X CETI—												
	2884.6	9.2	L,	2900.6	8.9	L,	2902.9	9.3	Wf,	2905.8	9.0	Pt.
032043 Y PERSEI—												
	2882.8	10.2	Pt,	2905.8	10.0	M,	2905.8	10.2	Pt.			
032335 R PERSEI—												
	2867.6	9.6	Gi,	2877.6	9.1	Gi,	2886.8	8.1	Pt,	2888.6	8.8	Gi,
	2901.6	8.8	Gi,	2905.8	8.7	Pt,	2910.8	9.3	M.			
033362 U CAMELOPARDALIS—												
	2905.8	8.6	M.									
041619 T TAURI—												
	2916.8	9.6	M.									
042215 W TAURI—												
	2898.8<10.4 M,			2905.7	13.0	Pt,	2916.8	12.0	M.			
042209 R TAURI—												
	2916.8	11.9	M.									
042309 S TAURI—												
	2916.8<12.0 M.											
043065 T CAMELOPARDALIS—												
	2844.5	8.0	L,	2857.4	7.7	L,	2867.5	7.9	L,	2877.4	8.4	L,
	2885.4	7.9	L,	2898.4	8.8	L,	2916.8	9.7	M.			
043274 X CAMELOPARDALIS—												
	2886.8	12.0	Pt,	2902.6	10.6	O.	2905.8	10.4	Pt,	2816.8	9.8	M.
043208 RX TAURI—												
	2916.8	10.5	M.									
044617 V TAURI—												
	2908.8	10.9	Pt,	2916.8	10.8	M.						
050953 R AURIGAE—												
	2886.8	9.0	Pt,	2905.8	8.4	Pt,	2916.8	8.5	M.			
052034 S AURIGAE—												
	2886.6	8.5	L,	2900.6	8.7	L,	2916.8	8.8	M.			
052036 W AURIGAE—												
	2884.6	8.9	L,	2900.6	9.0	L,	2901.6	8.7	Gi,	2905.8	9.1	Pt,
	2916.8	9.3	M.									
053068 S CAMELOPARDALIS—												
	2886.8	10.6	Pt,	2905.8	10.4	Pt,	2916.8	10.6	M.			

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
053326 RR TAURI—												
	2916.8	10.7	M.									
054319 SU TAURI—												
	2814.1	9.5	Ch,	2900.6	9.6	L,	2902.9	9.5	Wf,	2908.8	9.5	Pt,
	2916.8	9.5	M,	2916.8	9.6	Pt						
054974 V CAMELOPARDALIS—												
	2821.4	<14.0	Gi,	2848.5	<14.0	Gi,	2866.4	<14.0	Gi,	2876.5	<14.0	Gi,
	2901.4	13.7	Gi,	2916.8	11.4	M.						
054920 U ORIONIS—												
	2814.1	9.8	Ch,	2908.8	5.5	Pt,	2916.8	6.6	M.			
055353 Z AURIGAE—												
	2778.6	9.9	Ya,	2807.6	9.5	Ya,	2878.9	10.9	Wf,	2884.9	10.8	Wf,
	2886.8	10.8	Pt,	2895.9	10.7	Wf,	2902.9	10.5	Wf,	2908.8	10.4	Pt,
	2910.8	10.4	Wf.									
060547 SS AURIGAE—												
	2803.4	<12.4	L,	2811.1	10.8	Ch,	2814.1	11.4	Ch,	2816.1	<11.5	Ch,
	2837.6	<12.4	Y,	2842.6	<12.4	Y,	2846.4	<12.4	L,	2852.4	<12.4	L,
	2870.6	<11.5	L,	2880.5	<12.0	L,	2882.6	<12.4	L,	2884.6	<12.4	L,
	2886.6	<13.3	L,	2888.6	<12.4	Gi,	2898.6	<12.4	Gi,	2900.6	<12.0	L,
	2901.6	<13.3	Gi,	2901.8	<12.6	Pt,	2905.8	<12.4	Pt,	2908.8	<12.4	Pt,
	2916.8	<12.6	Pt.									
065355 R LYNCIS—												
	2898.6	8.8	Gi.									
070122a R GEMINORUM—												
	2809.1	<11.5	Ch.									
072708 S CANIS MINORIS—												
	2814.1	9.4	Ch,	2833.1	8.4	Ch.						
074922 U GEMINORUM—												
	2814.3	<13.7	L,	2840.6	<12.5	Du.	2852.4	<11.0	L.			
081112 R CANCRI—												
	2809.1	8.5	Ch,	2814.0	8.7	Jk,	2838.0	9.2	Jk.			
081617 V CANCRI—												
	2836.6	8.4	Du,	2845.4	8.1	Gi.						
083350 X URSAE MAJORIS—												
	2836.6	12.0	Du,	2840.6	12.4	Du.						
084803 S HYDRAE—												
	2811.1	<11.0	Ch,	2850.1	10.3	Ch.						
085008 T HYDRAE—												
	2814.1	9.7	Ch,	2814.3	9.8	L.						
085120 T CANCRI—												
	2852.4	8.3	L.									
093178 Y DRACONIS—												
	2836.7	<13.0	Du.									
093934 R LEONIS MINORIS—												
	2816.2	9.7	Ch.	2850.1	10.8	Ch,	2852.4	11.1	L.	2861.6	10.7	B,
	2865.4	11.3	L.									
094211 R LEONIS—												
	2758.5	7.6	Bp,	2764.4	7.9	Bp,	2781.4	8.2	Bp,	2793.4	8.3	Bp,
	2800.4	8.4	Bp,	2807.5	8.7	Gd,	2807.5	8.5	Bp,	2827.5	9.6	Bp,
	2833.4	9.4	Bp,	2846.4	10.0	Bp.						
094512 X LEONIS—												
	2852.4	11.9	L.									
103212 U HYDRAE—												
	2852.3	4.6	L.									
103769 R URSAE MAJORIS—												
	2811.1	<11.0	Ch,	2836.7	<12.9	Du,	2839.2	<11.0	Ch,	2867.6	<12.5	M,
	2873.7	12.0	Pt,	2878.7	<10.5	Lc,	2880.6	<11.0	Pc,	2895.6	<11.5	M,
	2898.7	11.0	Pt,	2903.6	<10.5	Ca,	2905.6	10.5	Ps,	2908.6	10.6	Pc.
104620 V HYDRAE—												
	2816.1	7.6	Ch,	2850.1	7.2	Ch.	2852.4	6.5	L.			
104814 W LEONIS—												
	2840.6	12.8	Du.									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
110506 S LEONIS—												
	2840.6	<12.8	Du.									
115919 R COMAE BERENICES—												
	2840.6	8.7	Du,	2855.6	8.4	Du,	2861.6	8.3	B,	2867.6	8.8	M.
	2880.0	8.0	Wf,	2885.7	8.6	Wf,	2901.7	9.1	Wf.	2908.7	9.3	Wf,
121418 R CORVI—												
	2848.4	7.4	Pe,	2852.4	8.3	Be,	2852.4	8.3	L,	2861.6	7.4	B,
	2865.4	8.2	L,	2867.6	8.1	Pt,	2872.3	8.4	L.			
122001 SS VIRGINIS—												
	2807.5	9.2	Bp,	2817.5	9.3	Bp,	2827.5	9.1	Bp,	2844.4	7.5	L,
	2846.5	8.8	Bp,	2857.4	7.5	L,	2859.4	7.0	L,	2883.4	6.8	L,
	2896.3	6.7	L.									
122532 T CANUM VENATICORUM—												
	2838.0	10.6	Jk,	2867.6	11.6	M,	2867.6	11.1	Pt,	2898.6	11.7	Pt.
122803 Y VIRGINIS—												
	2846.4	10.7	L,	2858.4	10.1	L,	2869.4	10.0	L,	2884.4	9.6	L.
123160 T URSAE MAJORIS—												
	2816.1	7.7	Ch,	2836.7	8.6	Du,	2838.0	8.8	Jk,	2839.2	9.0	Ch,
	2842.6	9.3	Ro,	2855.4	9.6	Pe,	2866.3	10.1	Pe,	2867.6	10.4	Gd,
	2867.6	10.9	Pt,	2868.8	11.0	M,	2869.2	10.8	Ch,	2875.0	10.8	Jk.
	2881.6	11.5	M,	2882.7	<10.9	Pc,	2895.6	12.0	M,	2900.6	<10.8	Pc,
	2901.7	<10.8	Ca,	2905.6	<11.0	Cl,	2905.6	<10.8	Ps,	2905.7	<11.1	Su,
	2906.6	<10.8	Jd,	2910.6	<11.7	Jd,	2914.6	<10.8	Pc.			
123307 R VIRGINIS—												
	2768.5	7.9	Bp,	2784.4	8.5	Bp,	2804.6	7.9	Ya,	2817.5	9.4	Bp,
	2840.6	10.4	Ya,	2848.4	10.5	Pe,	2852.4	11.0	L,	2853.5	10.0	Bp,
	2865.4	10.4	L,	2865.6	10.4	Ca,	2867.6	10.4	Pt,	2867.7	10.4	Lc,
	2871.4	10.3	L,	2872.8	10.1	Ka,	2878.6	9.2	Lc,	2882.4	9.0	L,
	2891.6	7.8	B,	2894.4	7.9	L,	2898.6	7.3	Pt.			
123459 RS URSAE MAJORIS—												
	2816.1	<11.5	Ch,	2836.7	<13.0	Du,	2839.2	<11.5	Ch,	2867.8	<13.7	Wf,
	2868.8	<12.5	M,	2880.8	13.3	M,	2880.8	12.9	Wf,	2882.7	<11.0	Pc,
	2885.8	12.7	Wf,	2895.8	11.8	Wf,	2898.6	11.6	Pt,	2900.6	11.0	Pc,
	2901.8	11.1	Wf,	2905.6	10.5	Cl,	2905.6	10.3	Ps,	2905.7	10.2	Su,
	2908.7	10.3	Wf,	2910.6	<10.6	Jd,	2910.6	<9.5	Cg,	2914.6	9.5	Pc.
123961 S URSAE MAJORIS—												
	2816.1	10.8	Ch,	2836.7	9.0	Du,	2839.2	9.0	Ch,	2842.6	8.5	Ro,
	2844.4	8.4	L,	2857.4	8.0	L,	2862.6	8.2	O,	2867.5	7.8	L,
	2867.6	8.5	Gd,	2867.6	7.8	Pt,	2868.8	8.1	M,	2869.2	8.2	Ch,
	2875.0	8.3	Jk,	2875.6	8.5	Ro,	2877.4	8.0	L,	2881.6	8.3	M,
	2881.6	8.4	Ro,	2882.7	8.2	Pc,	2885.4	7.9	L,	2885.6	8.3	O,
	2893.4	8.1	V,	2894.5	7.8	Ro,	2895.6	8.0	M,	2898.4	7.8	L,
	2898.6	8.3	O,	2898.7	8.1	Pt,	2900.6	8.0	Pc,	2901.7	8.2	Ca,
	2903.5	7.6	Ro,	2905.6	8.0	Cl,	2905.6	8.0	Ps,	2905.7	8.1	Su,
	2906.6	8.0	O,	2906.6	8.0	Jd,	2910.6	8.3	Cg,	1910.6	7.8	Jd,
	2914.6	7.6	Pc.									
124606 U VIRGINIS—												
	2867.6	8.5	Pt,	2898.6	10.2	Pt.						
130212 RV VIRGINIS—												
	2879.7	<11.2	Wf.									
132422 R HYDRAE—												
	2783.6	8.5	Gi,	2819.4	9.5	L,	2820.2	9.6	Ch,	2835.2	9.9	Ch,
	2837.2	9.8	Ch,	2852.4	9.7	L,	2857.4	9.3	Gi,	2865.4	9.3	L,
	2867.6	9.6	Lc,	2867.7	9.9	Pt,	2869.4	9.1	Gi,	2872.4	9.3	L,
	2884.4	8.5	Gi,	2894.3	9.0	L.						
132706 S VIRGINIS—												
	2850.1	10.4	Ch,	2858.7	9.8	B,	2865.6	<11.0	Ca.			
133273 T URSAE MINORIS—												
	2836.6	<13.0	Du,	2878.8	<12.8	Wf,	2884.8	<12.8	Wf,	2893.8	12.5	Wf,
	2901.8	12.3	Wf,	2908.7	12.3	Wf.						
133633 T CENTAURI—												
	2896.6	6.6	Bh.									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
134440 R CANUM VENATICORUM—												
	2838.0	7.7	Jk,	2862.8	8.2	M,	2865.6	8.4	O,	2867.7	8.1	Pt,
	2875.0	8.6	Jk,	2894.6	9.1	O,	2895.6	9.0	M,	2897.6	9.1	Pt,
	2906.6	9.6	O,	2910.6	10.0	Ya.						
135908 RR VIRGINIS—												
	2888.6	<12.1	M,	2898.6	11.7	Pt.						
140113 Z BOOTIS—												
	2867.7	10.5	M,	2879.7	11.4	Wf,	2885.8	11.9	Wf,	2893.8	12.2	Wf,
	2897.6	12.5	B,	2901.7	12.7	Wf,	2908.7	12.8	Wf.			
141567 U URSAE MINORIS—												
	2811.2	8.1	Ch,	2835.1	7.8	Ch,	2836.7	7.7	Du,	2842.6	8.2	Ro,
	2850.1	8.1	Ch,	2850.6	8.3	Hs,	2867.6	8.8	M,	2869.7	8.3	Pt,
	2882.6	8.7	Pc,	2897.6	10.0	Pt,	2900.6	9.9	Pc,	2911.6	9.8	Ya.
141954 S BOOTIS—												
	2809.1	11.0	Ch,	2852.5	12.9	L,	2853.5	12.7	Gi,	2864.8	<12.0	L,
	2865.4	12.5	Gi,	2866.4	12.8	L,	2867.7	12.1	Pt,	2876.4	12.4	Gi,
	2880.4	12.5	L,	2886.4	12.0	Gi,	2893.4	12.1	L,	2898.7	11.8	Pt,
	2900.4	11.4	Gi.									
142205 RS VIRGINIS—												
	2896.6	10.9	B.									
142584 R CAMELOPARDALIS—												
	2865.5	10.3	Gi,	2865.6	10.5	O,	2866.7	9.9	Wf,	2876.5	9.9	Gi,
	2879 8	9.7	Wf,	2884.8	9.3	Wf,	2886.5	9.5	Gi,	2892.6	9.5	O,
	2893.8	9.2	Wf,	2895.6	9.4	M,	2897.6	8.9	B,	2900.5	8.9	Gi,
	2901.8	9.0	Wf,	2902 6	9.3	O,	2902.9	8.9	Wf,	2904.8	8.8	Wf,
	2905.8	8.6	Wf,	2907.7	8.6	Wf,	2908.7	8.6	Wf,	2910.8	8.5	Wf,
	2911.6	8.4	Ya,	2911.8	8.5	Wf,	2912.8	8.4	Wf,	2913.8	8.3	Wf.
142539 V BOOTIS—												
	2857.4	7.5	L,	2862.8	6.8	M,	2865.7	7.4	Ca,	2867.5	7.5	L,
	2867.6	7.4	Gd,	2867.7	7.1	Pt,	2873.6	6.3	Su,	2874.6	7.2	Ya,
	2875.0	7.2	Jk,	2876.6	7.5	Pc,	2877.4	7.3	L,	2892.4	7.4	L,
	2894.6	7.5	O,	2895.7	7.4	M,	2897.6	7.8	Bh,	2897.6	7.3	Pt,
	2900.7	7.2	Pc,	2901.6	7.3	B,	2901.6	7.5	Ca,	2903.5	7.5	Ro,
	2905.6	7.6	Ps,	2905.7	7.6	Su,	2908.6	7.0	Jd,	2910.6	7.9	O,
	2910.6	7.8	Ya,	2914.6	7.3	Pc.						
143227 R BOOTIS—												
	2814.1	7.4	Ch,	2824.1	7.3	Ch,	2850.1	7.7	Ch,	2862.6	8.4	O,
	2862.8	8.1	M,	2865.7	8.2	Ca,	2867.6	8.6	Su,	2867.7	8.1	Pt,
	2874.6	8.8	Ya,	2875.1	8.8	Jk,	2891.6	9.7	B,	2892.6	9.7	O,
	2895.6	10.0	M,	2897.6	10.3	Pt,	2902.7	11.0	Su,	2903.6	10.3	Ca,
	2910.6	10.7	O,	2910.6	11.9	Ya.						
144918 U BOOTIS—												
	2851.4	10.6	Gi,	2862.4	10.1	Gi,	2867.7	10.3	M,	2873.4	10.1	Gi,
	2884.4	10.2	Gi,	2891.6	10.6	B,	2898.4	10.0	Gi.			
150018 RT LIBRAE—												
	2873.6	9.0	Pt,	2898.6	9.4	Pt.						
150605 Y LIBRAE—												
	2844.4	9.6	L,	2858.4	10.2	L,	2869.4	10.4	L,	2873.7	10.4	Pt,
	2882.4	11.2	L,	2894.4	12.5	L,	2897.7	12.2	B,	2898.6	12.4	Pt.
151520 S LIBRAE—												
	2837.2	9.1	Ch,	2848.5	10.2	L,	2862.4	10.8	L,	2871.4	11.2	L,
	2882.4	11.8	L,	2894.3	12.4	L.						
151731 S CORONAE BOREALIS—												
	2814.2	10.1	Ch,	2845.1	11.0	Ch,	2867.7	11.8	Pt,	2873.6	<11.1	Su.
	2876.6	<11.0	Pc,	2880.8	12.6	M,	2880.8	12.0	Wf,	2884.9	12.2	Wf,
	2893.8	12.6	Wf,	2895.6	<11.1	Su,	2897.6	12.4	Pt,	2901.6	<11.1	Ca,
	2901.8	12.8	Wf.	2903.7	12.9	B,	2908.6	<12.3	Jd.	2908.7	13.0	Wf.
151714 S SERPENTIS—												
	2846.4	12.1	L,	2853.4	12.0	L,	2865.4	12.0	L,	2866.8	12.0	Wf,
	2871.4	11.9	L,	2880.5	11.2	L,	2880.8	11.2	Wf,	2881.7	10.7	M,
	2885.8	10.5	Wf,	2892.6	9.0	B,	2893.4	9.7	L,	2893.8	9.6	Wf,

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
151714 S SERPENTIS—Continued.												
	2895.7	9.2	M.	2901.6	9.0	Ca.	2901.7	9.0	Wf.	2906.6	8.8	Ya.
	2908.7	8.9	Wf.									
151822 RS LIBRAE—												
	2848.5	11.7	L.	2864.4	12.5	L.	2872.4	12.0	L.	2882.4	11.7	L.
	2894.4	11.2	L.	2903.6	10.0	B.						
152714 RU LIBRAE—												
	2846.4	11.5	L.	2862.4	10.5	L.	2867.7	9.5	Mu.	2871.5	9.5	L.
	2873.7	8.9	Pt.	2882.4	8.8	L.	2894.4	8.2	L.	2898.6	8.5	Pt.
	2900.6	8.5	B.									
152849 R NORMAE—												
	2898.6	9.4	Bh.									
153215 W LIBRAE—												
	2866.4	13.0	L	2875.4	12.9	L.	2894.4	13.0	L.	2903.6	13.3	B.
153378 S URSAE MINORIS—												
	2842.6	10.4	Ro.	2866.7	9.7	Wf.	2867.6	10.0	Su.	2871.7	9.4	Pt.
	2872.7	9.4	M.	2875.6	9.3	Ro.	2879.8	9.7	Wf.	2881.6	9.0	Ro.
	2884.8	9.3	Wf.	2893.8	9.0	Wf.	2894.5	9.0	Ro.	2898.7	8.6	Pt.
	2899.5	8.8	Ro.	2900.6	8.8	V.	2901.7	8.6	Ca.	2901.8	8.8	Wf.
	2903.5	8.7	Ro.	2905.7	8.5	Su.	2906.7	8.6	M.	2906.6	8.6	Ya.
	2908.9	8.7	Wf.	2910.5	8.4	Ro.						
154428 R CORONAE BOREALIS—												
	2814.0	6.4	Jk.	2814.2	6.1	Ch.	2836.7	6.2	Du.	2838.1	6.9	Jk.
	2840.7	6.5	Du.	2842.5	6.6	Mt.	2842.6	6.2	Ro.	2843.5	6.4	L.
	2844.4	7.2	Au.	2844.4	6.7	Gi.	2844.4	6.5	L.	2845.1	6.1	Ch.
	2845.6	6.8	Hc.	2846.4	6.8	L.	2848.4	7.0	Gi.	2848.5	6.8	L.
	2849.4	7.0	Gi.	2849.4	7.1	L.	2849.6	7.3	Ap.	2852.4	7.1	Be.
	2852.4	7.3	L.	2852.4	7.3	Pe.	2853.3	7.4	Pe.	2853.4	7.2	Gi.
	2853.4	7.7	L.	2854.4	7.7	L.	2855.6	7.1	Du.	2857.4	7.2	Gi.
	2857.4	7.3	L.	2858.4	7.4	L.	2858.4	7.5	Be.	2861.3	7.5	Be.
	2861.3	7.0	L.	2862.4	7.4	Be.	2862.4	7.2	L.	2862.6	7.5	O.
	2862.7	7.4	M.	2863.4	7.0	Gi.	2863.4	7.2	L.	2864.4	7.4	L.
	2864.8	7.0	M.	2865.4	6.8	Pe.	2865.4	6.8	L.	2865.6	7.0	Ca.
	2865.6	7.0	O.	2865.6	7.2	Mo.	2866.2	6.6	Ch.	2866.4	7.4	Be.
	2866.4	6.8	L.	2866.4	6.7	Pe.	2866.6	7.2	Ap.	2867.6	7.0	Gd.
	2867.6	6.5	M.	2867.6	6.7	Ya.	2867.7	6.8	Mu.	2867.7	6.9	Pt.
	2867.8	6.6	Su.	2868.7	7.0	Wf.	2868.8	6.6	M.	2869.4	6.8	L.
	2869.7	6.8	Mu.	2869.7	6.7	Pt.	2870.5	6.6	L.	2870.8	7.0	M.
	2870.8	6.5	Pt.	2871.4	6.7	Gi.	2871.4	6.6	L.	2871.7	6.6	Ca.
	2871.7	6.9	Mu.	2871.7	6.4	Pt.	2871.7	7.4	Su.	2871.8	6.8	Ka.
	2871.8	7.0	M.	2872.4	6.7	L.	2872.7	6.9	M.	2872.7	6.6	Mu.
	2873.4	6.6	Be.	2873.4	6.5	L.	2873.6	6.6	Su.	2873.7	6.8	Mu.
	2873.8	6.6	M.	2874.7	6.9	Mu.	2874.7	6.6	Su.	2875.1	6.9	Jk.
	2875.4	6.3	L.	2875.7	6.7	Mu.	2876.7	7.1	Ap.	2876.7	7.1	Mu.
	2877.4	6.4	Be.	2877.4	6.8	Gi.	2877.4	6.3	L.	2877.7	6.7	Mu.
	2878.7	6.8	Mu.	2878.7	6.7	Pt.	2878.8	6.4	M.	2879.7	7.0	Mu.
	2879.7	6.7	Pt.	2879.8	7.0	Wf.	2880.4	6.5	L.	2880.7	7.0	Mu.
	2880.7	6.6	Pt.	2880.8	6.2	M.	2880.8	6.5	Wf.	2881.7	6.2	M.
	2881.8	6.7	Wf.	2882.4	6.6	Be.	2882.4	6.5	L.	2882.7	6.2	M.
	2882.7	6.9	Wf.	2882.7	6.9	Mu.	2882.8	6.5	Pt.	2883.4	6.7	Gi.
	2883.4	6.4	L.	2883.9	6.7	Wf.	2884.4	6.4	L.	2884.6	6.6	Cl.
	2884.8	6.4	M.	2884.8	6.9	Wf.	2885.4	6.5	L.	2885.6	6.7	O.
	2885.8	6.8	Wf.	2886.5	6.5	L.	2886.6	6.3	Pc.	2886.8	6.2	M.
	2886.8	6.5	Pt.	2886.8	6.5	Wf.	2887.6	6.9	Gd.	2887.7	6.8	Wf.
	2888.4	6.7	L.	2888.6	6.2	M.	2888.6	6.5	Su.	2888.8	6.8	Wf.
	2889.8	6.7	Wf.	2890.8	6.8	Wf.	2891.4	6.6	L.	2891.8	6.8	Wf.
	2892.3	6.5	L.	2892.6	6.7	Hc.	2892.6	6.7	O.	2892.7	6.9	Wf.
	2893.4	6.4	L.	2893.8	6.9	Wf.	2894.4	6.4	L.	2894 6	6.7	O.
	2894.8	6.8	Wf.	2895.4	6.3	L.	2895.6	6.6	Su.	2895.7	7.1	Mu.
	2895.8	6.8	Wf.	2896.4	6.3	L.	2896.6	6.2	Ya.	2897.4	6.7	Gi.
	2897.6	6.5	Bh.	2897.6	6.4	Pt.	2897.7	7.0	Mu.	2897.8	6.8	Wf.

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
154428 R CORONAE BOREALIS—Continued.												
	2898.4	6.3	L,	2898.6	6.7	Bh,	2898.6	6.5	O,	2898.6	6.4	Pt,
	2898.7	7.1	Mu,	2899.4	6.2	L,	2899.7	7.0	Mu,	2899.9	6.9	Wf,
	2900.6	6.6	V,	2900.7	7.0	Mu,	2900.7	6.3	Pt,	2900.7	6.3	Pe,
	2900.9	6.9	Wf,	2901.4	6.3	L,	2901.6	6.6	Ca,	2901.6	6.5	O,
	2901.7	7.1	Mu,	2901.7	6.8	Wf,	2902.3	6.3	L,	2902.5	6.7	Cg,
	2902.6	6.5	O,	2902.7	6.6	Su,	2902.8	6.8	Wf,	2903.5	6.6	Ro,
	2903.7	7.1	Mu,	2903.7	6.7	Wf,	2904.8	6.7	Wf,	2905.6	6.7	O,
	2905.6	6.3	Ps,	2905.7	6.8	Mu,	2905.7	6.6	Su,	2905.8	6.3	Pt,
	2906.6	6.4	Ca,	2906.6	6.9	Hc,	2906.6	6.7	O,	2906.7	6.7	Mu,
	2906.7	6.3	Pt,	2907.6	6.8	Cl,	2907.6	6.5	Pc,	2907.7	6.7	Wf,
	2908.6	7.0	Jd,	2908.6	6.8	Jd,	2908.6	6.7	O,	2908.8	6.5	Wf,
	2909.7	6.3	Pt,	2910.5	6.6	Cg,	2910.6	6.5	Cl,	2910.6	6.6	O,
	2910.6	6.5	Ps,	2910.6	6.4	Pc,	2910.8	6.9	Wf,	2911.6	6.4	Ca,
	2911.7	6.4	Pt,	2911.8	6.9	Wf,	2912.6	6.6	O,	2912.8	7.0	Wf,
	2913.8	7.0	Wf,	2914.7	6.2	Pt,	2917.6	6.6	O,	2921.6	6.5	Hc.
154536 X CORONAE BOREALIS—												
	2866.8	13.3	Wf,	2880.7	12.9	Wf,	2885.8	12.9	Wf,	2886.7	<12.2	M,
	2893.8	12.4	Wf,	2901.7	12.2	Wf,	2908.8	12.0	Wf.			
154639 V CORONAE BOREALIS—												
	2862.8	10.2	M,	2869.7	10.7	Pt,	2879.7	10.3	Wf,	2885.8	10.1	Wf,
	2893.8	10.4	Wf,	2895.7	9.7	M,	2898.7	10.1	Pt,	2901.8	10.1	Wf,
	2908.8	8.9	Wf.									
154615 R SERPENTIS—												
	2845.1	10.0	Ch,	2866.4	11.1	Pe,	2867.7	10.6	M,	2867.7	10.8	Pt,
	2871.7	10.7	Ca,	2871.5	10.8	Jk,	2892.7	11.8	B,	2895.7	10.8	M,
	2897.7	11.7	Pt,	2900.7	<11.1	V,	2910.6	12.2	Ya,	2912.6	<10.9	Hc,
155018 RR LIBRAE—												
	2811.2	<11.0	Ch,	2837.2	<11.0	Ch,	2848.5	14.0	L,	2864.4	13.8	L,
	2872.4	13.8	L,	2892.4	12.0	L.						
155847 X HERCULIS—												
	2867.7	6.2	Mu,	2869.7	6.5	Mu,	2871.7	6.5	Mu,	2872.7	6.6	Mu,
	2873.7	6.6	Mu,	2874.7	6.7	Mu,	2875.7	6.6	Mu,	2876.7	6.7	Mu,
	2877.7	6.6	Mu,	2878.7	6.6	Mu,	2879.7	6.4	Mu,	2880.7	6.5	Mu,
	2882.7	6.5	Mu,	2895.7	6.6	Mu,	2897.7	6.6	Mu,	2898.7	6.6	Mu,
	2899.7	6.6	Mu,	2900.7	6.6	Mu,	2901.7	6.6	Mu,	2903.7	6.6	Mu,
	2905.7	6.5	Mu,	2906.7	6.5	Mu.						
155823 RZ SCORPII—												
	2871.7	9.6	Pt,	2897.7	11.1	Pt.						
160021 Z SCORPII—												
	2852.4	12.0	L,	2865.4	12.3	L,	2875.4	12.1	Pt,	2892.4	11.7	Pt.
160118 R HERCULIS—												
	2845.1	8.5	Ca,	2867.1	8.6	Ch,	2867.7	8.7	M,	2894.7	9.6	Ya,
	2895.7	9.7	M,	2905.6	9.6	Cl,	2905.6	9.5	Pc,	2906.6	9.6	B,
160210 U SERPENTIS—												
	2867.6	10.3	M,	2869.7	10.4	Pt,	2875.1	10.6	Jk,	2892.7	<12.3	B,
	2895.6	12.0	M,	2896.6	11.6	Ya,	2898.7	11.8	Pt,	2903.6	<11.0	Pw,
	2905.6	11.5	Cl,	2906.6	11.5	Pc.						
160625 RU HERCULIS—												
	2866.7	<12.3	Wf,	2867.7	<11.7	M.	2879.8	<12.3	Wf,	2884.7	<12.3	Wf,
	2893.8	12.2	Wf,	2901.8	12.1	Wf,	2908.8	<12.3	Wf,	2914.6	<10.5	Pc.
161138 W CORONAE BOREALIS—												
	2866.7	12.4	Wf,	2879.8	11.9	Wf,	2885.8	12.4	Wf,	2886.7	<12.5	M,
	2893.8	11.6	Wf,	2901.8	11.3	Wf,	2908.8	11.1	Wf.			
161122a R SCORPII—												
	2853.4	<11.0	Pe.									
161122b S SCORPII—												
	2853.4	<11.0	Pe,	2903.6	<10.6	Pw.						
161122c T SCORPII—												
	2903.6	<10.6	Pw.									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
161607 W OPHIUCHI—												
	2846.4	11.0	L,	2864.4	11.8	L,	2869.6	11.9	Pt,	2871.5	12.0	L,
	2880.5	12.4	L,	2896.4	12.7	L,	2896.6	<11.0	Ya.			
162112 V OPHIUCHI—												
	2853.2	10.2	Ch,	2869.6	10.1	Pt,	2898.7	10.0	Pt,	2906.6	9.4	Ca,
	2906.7	8.8	B.									
162119 U HERCULIS—												
	2815.2	10.2	Ch,	2845.1	<10.4	Ch,	2848.4	10.9	Gi,	2853.4	11.9	Pe,
	2863.4	11.4	Gi,	2866.4	11.6	Pe,	2867.7	11.5	M,	2869.7	11.8	Pt,
	2869.7	<11.3	Pc,	2873.4	11.2	Gi,	2873.6	<11.1	Su,	2884.4	11.5	Gi,
	2895.6	<11.1	Su,	2895.7	<11.6	M,	2897.6	<10.9	Bh,	2898.4	11.8	Gi,
	2898.7	11.9	Pt,	2903.7	12.5	B.						
162319 Y SCORPII—												
	2845.4	<13.5	Gi,	2852.4	<13.4	L,	2866.4	<13.5	Gi,	2866.4	<12.0	L,
	2873.4	12.0	L,	2876.4	14.0	Gi,	2896.4	12.8	L,	2898.4	13.5	Gi.
162542 g HERCULIS—												
	2867.7	5.1	Mu,	2869.7	5.3	Mu,	2871.7	5.2	Mu,	2872.7	5.2	Mu,
	2873.7	5.3	Mu,	2874.7	5.2	Mu,	2875.7	5.2	Mu,	2876.7	5.2	Mu,
	2877.7	5.2	Mu,	2878.7	5.1	Mu,	2879.7	5.2	Mu,	2880.7	5.1	Mu,
	2882.7	5.2	Mu,	2895.7	5.1	Mu,	2897.7	5.3	Mu,	2898.7	5.4	Mu,
	2900.7	5.4	Mu,	2901.7	5.4	Mu,	2903.7	5.4	Mu,	2905.7	5.4	Mu,
	2906.7	5.4	Mu.									
162807 SS HERCULIS—												
	2843.6	13.0	L,	2863.4	10.8	L,	2867.6	10.2	Gd,	2868.8	10.0	M,
	2869.6	10.0	Pt,	2871.4	10.5	L,	2880.5	9.3	L,	2891.4	9.4	L,
	2892.6	9.3	B,	2894.6	9.6	Ya,	2895.7	9.5	M.			
162815 T OPHIUCHI—												
	2853.4	11.8	L,	2866.4	12.3	L,	2873.4	12.2	L,	2896.4	12.8	L.
162816 S OPHIUCHI—												
	2853.4	10.4	L,	2866.4	10.4	L,	2873.4	10.4	L,	2892.4	10.6	L.
163172 R URSAE MINORIS—												
	2867.8	10.2	M,	2895.7	9.5	M,	2897.6	9.3	B.			
163137 W HERCULIS—												
	2815.2	<11.0	Ch,	2852.1	9.7	Ch,	2862.8	9.5	M,	2871.7	9.3	Pt,
	2882.8	8.8	M,	2894.6	8.5	Ya,	2895.6	8.5	M,	2897.7	8.2	Pt,
	2900.7	8.4	V,	2905.6	8.5	Pc,	2906.6	8.6	B.			
163266 R DRACONIS—												
	2816.1	<11.0	Ch,	2839.2	<11.0	Ch,	2867.7	8.9	M,	2871.7	9.0	Pt,
	2895.7	7.1	M,	2896.6	7.2	Ya,	2902.6	6.8	O,	2905.8	7.1	Pt,
	2906.6	7.2	Pc.									
164055 S DRACONIS—												
	2862.8	8.8	M.									
164319 RR OPHIUCHI—												
	2864.4	<12.0	L,	2873.4	<13.0	L,	2896.4	12.7	L.			
164715 S HERCULIS—												
	2853.4	10.2	Gi,	2865.4	10.3	Gi,	2867.6	10.3	M,	2869.1	10.4	Ch,
	2871.8	10.7	Pt,	2876.4	10.7	Gi,	2886.4	10.8	Gi,	2894.6	11.3	Ya,
	2901.4	11.5	Gi.	2901.6	<10.5	Ca.	2905.8	11.8	Pt.			
165631 RV HERCULIS—												
	2880.7	<13.7	M.									
170215 R OPHIUCHI—												
	2820.2	8.5	Ch,	2837.2	9.3	Ch,	2853.4	11.0	Pc,	2867.7	10.5	Lc,
	2868.8	10.6	M,	2871.8	10.5	Pt,	2878.7	10.8	Lc,	2880.6	11.0	Lc,
	2903.6	<10.7	Ca,	2905.6	10.4	Ps,	2906.6	<10.7	Ya,	2908.6	<11.0	Pc.
170627 RT HERCULIS—												
	2872.8	<13.0	M,	2878.8	<13.0	Wf,	2884	<13.0	Wf,	2894.8	<13.0	Wf,
	2901.8	12.4	Wf,	2908.8	<13.0	Wf.						
171401 Z OPHIUCHI—												
	2853 4	10.8	Gi,	2865.4	11.2	Gi,	2869.7	11.5	Pt,	2876.5	11.6	Gi,
	2886.4	11.6	Gi	2888.6	<11.8	M,	2900.4	12.0	Gi,	2900.7	12.0	Pt,
	2903.7	<11.2	Ca.									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
171723 RS HERCULIS—												
	2864.8	<12.0	M,	2871.8	12.3	Pt,	2878.8	12.1	Wf,	2884.8	11.3	Wf,
	2894.9	10.6	Wf,	2895.6	10.5	M,	2897.7	9.8	Pt,	2901.8	10.1	Wf,
	2908.9	9.8	Wf,	2910.6	12.4	Pw.						
172809 RU OPHIUCHI—												
	2867.7	11.3	M,	2869.7	11.2	Pt,	2895.7	12.7	M,	2900.7	12.5	M.
174406 RS OPHIUCHI—												
	2869.7	11.4	Pt,	2900.7	10.4	Pt.						
175458a T DRACONIS—												
	2853.5	10.3	Gi,	2865.4	10.1	Gi,	2875.4	10.1	Gi,	2880.8	9.8	M,
	2885.4	10.1	Gi,	2906.7	11.0	Ya,	2916.8	10.5	M.			
175458b UY DRACONIS—												
	2880.8	11.0	M,	2916.8	<11.5	M.						
175519 RY HERCULIS—												
	2820.2	11.6	Ch,	2835.2	9.8	Ch,	2843.4	9.4	Pe,	2850.2	8.6	Ch,
	2853.3	9.2	Pe,	2862.8	8.8	M,	2867.1	8.4	Ch,	2869.7	8.1	Pt,
	2888.6	9.0	M,	2895.7	9.8	M,	2900.7	10.1	Pt,	2911.7	10.4	Ya.
175654 V DRACONIS—												
	2886.7	<12.8	M.									
180531 T HERCULIS—												
	2820.2	11.2	Ch,	2835.2	9.6	Ch,	2843.3	9.1	Pe,	2845.2	9.3	Ch,
	2848.3	9.1	Pe,	2852.5	9.0	L,	2853.4	8.8	Pe,	2858.6	8.6	L,
	2864.8	9.1	M,	2865.3	8.5	Pe,	2867.1	8.7	Ch,	2869.4	8.1	L,
	2869.7	9.1	Pe,	2873.6	9.0	Su,	2880.5	8.6	L,	2891.4	9.0	L,
	2892.6	8.9	Pe,	2895.7	9.0	M,	2896.5	9.5	Ro,	2900.7	9.5	Pt,
	2901.6	9.5	V,	2902.6	9.6	L,	2902.6	9.4	Su,	2905.6	9.6	Ps,
	2906.7	9.6	Ca,	2910.6	9.6	Pe,	2911.6	10.1	Ya.			
180911 NOVA OPHIUCHI #4—												
	2845.4	11.4	Gi,	2852.5	11.6	L,	2865.4	11.4	L,	2871.4	11.4	Gi,
	2875.4	11.5	L,	2883.4	11.5	Gi,	2886.6	11.2	L,	2898.7	11.5	Pt,
	2899.4	11.8	Gi,	2901.4	11.3	L.						
181031 TV HERCULIS—												
	2848.5	<14.0	L,	2865.4	<14.0	L,	2880.4	<14.0	L,	2901.4	<14.0	L.
181136 W LYRAE—												
	2843.3	8.5	Pe.	2844.4	8.1	L,	2855.4	8.3	Pe,	2857.4	7.8	L,
	2862.6	7.8	O,	2867.5	7.8	L,	2867.6	7.9	M,	2867.6	8.1	Su,
	2867.7	7.7	Mu,	2873.0	7.8	Jk,	2873.6	7.5	Pt,	2877.4	7.7	L,
	2885.4	8.0	L,	2898.4	9.0	L,	2900.7	9.1	Pt,	2902.6	9.4	Su,
	2905.6	9.1	Ps,	2906.7	9.3	M.						
181103 RY OPHIUCHI—												
	2865.5	13.5	Gi,	2875.4	13.6	Gi,	2878.8	<13.0	Wf,	2884.8	<13.0	Wf,
	2885.4	13.5	Gi,	2894.9	12.4	Wf,	2898.5	12.1	Gi,	2901.9	12.1	Wf,
	2908.9	11.5	Wf.									
182224 SV HERCULIS—												
	2852.5	<13.9	L,	2865.4	13.8	L,	2871.8	12.6	M,	2880.4	<14.0	L,
	2894.4	14.2	L.									
182306 T SERPENTIS—												
	2871.8	<12.6	M.									
183225 RZ HERCULIS—												
	2871.8	<12.2	M,	2895.7	<11.6	M.						
183308 X OPHIUCHI—												
	2848.5	7.1	L,	2857.4	7.0	L,	2867.2	7.3	Ch,	2867.7	7.8	M,
	2869.4	7.2	L,	2869.7	7.0	Pt,	2880.5	7.7	L,	2893.4	7.9	L,
	2898.8	8.2	M,	2900.7	8.0	Pt.						
184134 RY LYRAE—												
	2867.7	10.4	M,	2873.7	10.6	Pt,	2895.6	11.0	M,	2898.6	11.5	Pt.
184243 RW LYRAE—												
	2873.7	11.7	Pt,	2884.8	12.0	M,	2902.8	12.0	M.			
184205 R SCUTI—												
	2813.4	7.0	Ch,	2842.4	5.7	Pe,	2848.5	5.3	Gi,	2850.2	5.4	Ch,
	2852.4	5.5	Pe,	2852.5	5.1	L,	2854.5	5.0	L,	2856.4	5.3	Pe,
	2858.5	5.2	L,	2858.6	5.1	Gi,	2864.4	5.3	L,	2864.8	5.0	M,

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
184205 R SCUTI—Continued.												
	2865.5	5.2	Gi,	2865.6	5.6	Ca,	2866.4	5.2	L,	2867.7	5.5	Pt,
	2868.2	5.5	Ch,	2869.4	5.8	Pe,	2869.7	5.4	Pt,	2870.8	5.4	Pt,
	2871.5	5.3	Gi,	2871.5	5.2	L,	2871.7	5.6	Ca,	2871.8	5.5	Ka,
	2871.8	5.3	Pt,	2873.7	5.6	Pt,	2873.7	5.4	Su,	2874.6	5.4	Su,
	2877.4	5.4	Gi,	2877.4	5.2	L,	2878.7	5.4	Pt,	2879.7	5.5	Pt,
	2880.7	5.7	Pt,	2882.7	5.3	Pc,	2882.8	5.6	Pt,	2883.4	5.5	Gi,
	2883.4	5.2	L,	2886.8	5.6	Pt,	2892.6	5.5	Pc,	2893.5	5.1	L.
	2894.6	5.8	O,	2895.6	5.0	M,	2895.6	5.2	Su,	2895.7	5.8	Mu,
	2896.6	6.0	Bh,	2897.4	6.0	Gi,	2897.6	5.8	Bh,	2897.7	5.8	Pt,
	2897.7	6.0	Mu,	2898.6	6.0	B,	2898.6	5.8	Pt,	2898.7	6.0	Mu,
	8299.7	6.0	Mu,	2900.7	6.0	Mu,	2900.7	5.7	Pt_s,	2901.6	5.6	Ca,
	2901.6	5.9	O,	2901.7	6.0	Mu,	2901.8	5.6	Pt,	2902.5	6.5	Ro,
	2902.6	5.5	L,	2902.7	5.1	Su,	2903.5	6.5	Ro,	2903.7	5.6	Ca,
	2903.7	6.1	Mu,	2905.6	5.8	Cl,	2905.6	5.1	Ps,	2905.6	5.7	Pc,
	2905.7	6.0	Mu,	2905.7	5.1	Su,	2905.8	5.7	Pt,	2906.6	5.6	Ca,
	2906.6	5.8	O,	2906.7	5.9	Mu,	2907.6	5.6	Cl,	2908.6	5.9	O,
	2909.7	5.9	Pt,	2910.5	6.1	Ro,	2910.6	5.5	Cl,	2910.6	6.0	O,
	2910.6	5.0	Ps,	2910.6	5.7	Pc,	2910.7	5.9	Pt,	2910.7	5.6	Ya,
	2911.6	5.7	Ca,	2911.7	6.0	Pt,	2914.7	5.8	Pt.			
184300 NOVA AQUILAE #3—												
	2813.4	9.0	Ch,	2842.6	9.8	Ro,	2845.4	9.7	Gi,	2850.2	9.1	Ch,
	2852.5	9.5	L,	2858.6	9.7	Gi,	2864.8	9.3	M,	2865.4	9.4	L,
	2867.7	9.5	Pt,	2869.4	9.7	Mt,	2871.4	9.7	Gi,	2871.8	9.2	Ka,
	2872.8	9.1	Ka,	2873.7	9.3	Pt,	2875.4	9.6	L,	2875.6	9.7	Ro,
	2878.7	9.7	Pt,	2879.6	9.7	Ro,	2881.6	9.7	Ro,	2882.7	9.9	Pc,
	2883.4	9.7	Gi,	2886.6	9.3	L,	2886.8	9.4	Pt,	2894.5	9.7	Ro,
	2895.6	9.4	M,	2896.5	9.6	Ro,	2897.7	9.6	Pt,	2898.4	9.0	L,
	2900.4	9.8	Gi,	2900.7	9.7	V,	2901.7	9.9	Ca,	2902.5	9.8	Ro,
	2903.5	9.8	Ro,	2903 6	8.8	Cl,	2905.7	10.0	Pc,	2905.8	9.6	Pt,
	2911.7	9.1	Ya,	2914.7	9.5	Pt.						
184929 NOVA LYRAE #1—												
	2849.4	13.4	Gi,	2899.4	13.4	Gi.						
185032 RX LYRAE—												
	2880.7<15.0 M.											
185512a ST SAGITTARII—												
	2843.6<12.5 L.			2866.5<12.5 L.			2880.4<13.5 L.			2898.4<13.0 L.		
185634 Z LYRAE—												
	2865.4<13.8 L.			2880.4<13.5 L.			2896.4<13.3 L.					
190108 R AQUILAE—												
	2867.2	9.8	Ch.	2867.7	9.3	M,	2869.7	9.0	Pt.	2900.7	7.0	Pt,
	2906.6	6.8	B.	2910.6	6.5	Pc,	2910.8	7.2	M.	2912.6	6.3	Pw.
190529a V LYRAE—												
	2867.7	12.1	Pt.									
190925 S LYRAE—												
	2846.4	14.0	L.	2865.4	13.5	L.	2880.4	14.0	L.	2896.4	14.5	L.
190926 X LYRAE—												
	2867.7	9.0	Pt.	2870.8	9.1	M.	2898.7	9.0	Pt.	2908.8	8.4	M.
190933a RS LYRAE—												
	2850.2<11.2 Ch.											
190967 U DRACONIS—												
	2872.8	13.1	M.	2902.8<12.1 M.			2910.6	11.6	Ps.			
191007a W AQUILAE—												
	2886.8	10.8	M.	2910.6	8.5	Pc.						
191007b TY AQUILAE—												
	2886.8	10.4	M.									
191017 T SAGITTARII—												
	2908.7	10.5	Pc.									
191019 R SAGITTARII—												
	2867.7	**10.4**	**Mu,**	**2867.7**	**10.4**	**Pt,**	2897.7	8.8	Pt.	2903.7	8.8	Ca,
	2908.6	**10.1**	**Pc.**									

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
191033 RY SAGITTARII—												
	2843.5	7.6	L,	2848.5	7.8	L,	2852.5	7.8	L,	2858.5	8.0	L,
	2864.5	8.8	L,	2867.7	8.5	Pt,	2869.7	8.6	Pt,	2870.6	8.9	L,
	2870.8	8.7	Pt,	2871.5	8.9	L,	2871.8	8.8	Pt,	2873.7	8.9	Pt,
	2878.7	9.4	Pt,	2879.7	9.7	Pt,	2880.5	9.7	L,	2880.7	9.5	Pt,
	2882.8	9.5	Pt,	2893.5	9.2	L,	2895.4	9.3	L,	2896.6	9.6	Bh,
	2897.6	9.8	Bh,	2897.7	9.8	Pt,	2898.6	9.8	Bh,	2898.7	9.7	Pt,
	2899.4	9.5	L,	2900.7	9.6	Pt,	2905.8	9.6	Pt,	2909.7	9.7	Pt.
191350 TZ CYGNI—												
	2867.7	10.9	Pt,	2898.6	11.0	Pt,	2920.8	10.0	M.			
191319 S SAGITTARII—												
	2845.5	<13.1	Gi,	2869.5	12.6	Gi,	2882.4	12.0	Gi,	2898.5	11.0	Gi,
	2903.7	10.2	Ca,	2908.6	10.2	Pc.						
191321 Z SAGITTARII—												
	2845.5	<12.4	Gi,	2869.5	<12.4	Gi,	2882.4	<12.4	Gi,	2898.5	<12.4	Gi.
191637 U LYRAE—												
	2867.6	10.7	M,	2867.7	10 8	Pt,	2898.7	10.2	Pt,	2902.8	10.3	M,
	2912.6	9.2	Pw.									
192928 TY CYGNI—												
	2850.2	<11.9	Ch.									
193311 RT AQUILAE—												
	2850.3	<12.1	Ch,	2867.7	<11.0	M.						
193449 R CYGNI—												
	2820.2	8.8	Ch,	2842.3	9.1	Ch,	2843.3	7.9	Pe,	2852.4	10.0	Pe,
	2856.4	10.0	Pe,	2857.3	10.0	Pe,	2862.6	9.5	O,	2865.3	10.1	Pe,
	2866.3	10.1	Pe,	2867.6	9.8	M,	2867.7	10.0	Mu,	2867.7	9.8	Pt,
	2869.2	10.2	Ch,	2869.7	9.9	Pc,	2895.6	11.2	M,	2898.6	9.6	O,
	2898.7	10.3	P.,	2901.6	11.3	B,	2901.6	<11.3	V,	2910.7	11.1	Pc,
	2910.7	11.8	Ya.									
193509 RV AQUILAE—												
	2886.8	12.8	M,	2905.8	11.8	M.						
193732 TT CYGNI—												
	2884.8	8.7	M,	2902.8	8.2	M.						
194048 RT CYGNI—												
	2820.2	<11.0	Ch,	2842.3	10.5	Ch,	2843.3	9.9	Pe,	2845.4	9.9	Pe,
	2850.5	9.2	Gi,	2852.4	9.5	Pe,	2856.4	9.2	Pe,	2857.4	9.1	Pe,
	2862.4	8.9	Gi,	2862.6	9.0	O,	2865 3	8.5	Pe,	2866.4	8.5	Pe,
	2867.6	8.5	M,	2867.7	8.3	Mu,	2867.7	8.4	Pt,	2869.2	8.3	Ch,
	2869.7	8.3	Pc,	2872.4	8.1	Gi,	2883.5	7.8	Gi,	2886.6	8.0	Pc,
	2895.6	6.8	M,	2898.6	7.5	O,	2898.7	7.0	Pt,	2899.4	7.6	Gi,
	2901.6	8.0	V,	2906.6	7.2	Pc,	2912.6	9.7	Pw.			
194348 TU CYGNI—												
	2845.4	10.1	Pe,	2852.4	10.7	Pe,	2865.3	<10.9	Pe,	2866.3	<11.2	Pe,
	2867.6	11.5	M,	2867.7	11.6	Pt,	2895.6	12.3	M,	2906.6	<11.2	Pc.
194604 X AQUILAE—												
	2866.8	<12.9	Wf,	2880.8	<12.9	Wf,	2885.9	<12.9	Wf,	2886.8	<12.3	M,
	2901.9	<12.9	Wf,	2908.9	<12.9	Wf,	2910.6	<10.2	Jd.			
194632 χ CYGNI—												
	2820.3	<11.0	Ch,	2842.3	<11.0	Ch,	2843.3	10.7	Pe,	2845.4	10.7	Pe,
	2848.4	10.5	Pe,	2855.4	10.5	Pe.	2856.4	10.5	Pe,	2857.4	10.4	Pe,
	2865.3	10.3	Pe,	2866.3	10.3	Pe,	2867.7	10.6	Lc,	2867.7	10.0	M,
	2867.7	10.2	Pt,	2873.3	8.9	Rk,	2878.7	<10.6	Lc,	2881.5	8.0	Rk,
	2881.7	8.6	M,	2882.4	7.9	Rk,	2892.6	6.4	B,	2896.4	6.1	Rk
	2897.7	6.0	Pt,	2898.6	5.5	O,	2900.6	5.6	B,	2901.6	5.8	V,
	2902.8	5.8	M,	2903.6	5.3	Ca,	2903.6	5.0	Cl,	2906.6	5.5	O,
	2907.6	5.3	Pc,	2910.6	5.4	O,	2910.6	4 9	Cl.	2910.7	5.5	Ps,
	2910.7	5.4	Ya,	2912.6	6.1	Pw,	2914.6	5.1	O,	2917.6	5.1	O.
195116 S SAGITTAE—												
	2867.7	5.7	Mu,	2869.7	6.3	Mu,	2871.7	5.8	Mu,	2872.7	5.5	Mu.
	2873.7	5.4	Mu,	2874.7	5.9	Mu,	2875.7	6.1	Mu,	2876.7	6.3	Mu,
	2877.7	6.0	Mu,	2878.7	6.0	Mu,	2879.7	5.3	Mu,	2880.7	5.3	Mu,

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
195116 S SAGITTAE—Continued.												
	2882.7	5.7	Mu,	2895.7	6.2	Mu,	2897.7	5.8	Mu,	2898.7	5.5	Mu,
	2899.7	5.4	Mu,	2900.7	5.8	Mu,	2901.7	6.0	Mu,	2903.7	6.2	Mu,
	2905.6	5.6	O,	2905.7	5.4	Mu,	2906.6	5.5	O,	2906.7	5.3	Mu,
	2907.6	5.6	O,	2908.6	5.7	O,	2910.6	5.9	O,	2912.6	5.7	O,
	2917.6	5.8	O.									
195202 RR AQUILAE—												
	2884.8	10.6	M,	2902.8	11.2	M,	2906.6	11.9	B.			
195308 RS AQUILAE—												
	2884.8	10.5	M,	2902.8	11.0	M.						
195553 NOVA CYGNI #3—												
	2844.5	10.0	Gi,	2848.5	9.2	L,	2848.5	9.9	Mt,	2858.4	10.1	Gi,
	2862.4	9.0	Be,	2862.4	9.1	L,	2864.7	9.5	Pt,	2867.7	9.5	Pt,
	2869.5	10.2	Mt,	2869.7	9.6	Pc,	2871.4	9.8	Gi,	2871.5	9.0	L,
	2872.8	9.4	Ka,	2873.6	9.4	Pt,	2875.6	9.6	Ro,	2879.6	9.7	Ro,
	2878.7	9.5	Pt,	2881.6	9.7	Ro,	2883.5	10.3	Gi,	2885.4	9.5	L,
	2886.8	9.5	Pt,	2894.5	9.8	Ro,	2897.7	9.6	Pt,	2898.4	9.7	L,
	2899.4	10.3	Gi,	2899.5	9.9	Ro,	2900.7	9.4	Pt,	2901.6	9.7	V,
	2902.5	9.8	Ro,	2903.5	9.9	Ro,	2905.8	9.5	Pt,	2906.7	9.8	Pc,
	2908.8	9.5	Pt,	2910.5	9.9	Ro,	2911.6	9.7	Ya,	2916.8	9.6	Pt.
195849 Z CYGNI—												
	2850.5	<13.8	Gi,	2866.1	<13.8	Gi,	2867.6	<11.6	M,	2873.7	12.4	Pt,
	2877.4	14.0	Gi,	2878.8	<12.7	Wf,	2884.8	<12.7	Wf,	2894.9	12.7	Wf,
	2898.4	12.6	Gi,	2898.7	12.7	Pt,	2901.6	12.4	B,	2901.9	12.6	Wf,
	2902.8	12.5	M,	2908.5	11.9	Wf.						
200212 SY AQUILAE—												
	2846.5	11.5	L,	2864.4	11.9	L,	2872.4	11.9	L,	2884.4	12.2	L,
	2898.8	12.3	M,	2899.4	12.3	L.						
200357 S CYGNI—												
	2869.7	13.5	Pt.									
200514 R CAPRICORNI—												
	2845.5	9.9	Gi,	2858.6	9.9	Gi,	2870.5	10.1	Gi,	2882.5	10.4	Gi,
	2886.8	11.6	M,	2898.5	10.9	Gi.						
200647 SV CYGNI—												
	2867.7	9.3	M,	2867.7	8.8	Mu,	2905.8	9.1	M.			
200747 RX CYGNI—												
	2867.7	7.8	Mu.									
200715a S AQUILAE—												
	2849.4	9.4	Gi,	2862.5	9.2	Gi,	2862.8	9.0	M,	2867.7	9.4	Mu,
	2869.7	9.8	Pt,	2872.4	9.5	Gi,	2883.4	10.6	Gi,	2895.7	9.5	M,
	2897.4	9.4	Gi,	2897.7	9.7	Pt,	2906.6	9.4	B,	2907.6	9.3	Cl,
	2911.7	9.6	Ya.									
200715b RW AQUILAE—												
	2862.8	8.8	M,	2867.7	9.8	Mu,	2895.7	8.8	M,	2906.6	9.3	B,
	2907.6	9.4	Cl,	2911.7	9.4	Ya.						
200812 RU AQUILAE—												
	2901.7	12.7	B.									
200822 W CAPRICORNI—												
	2871.7	11.7	Pt.									
200906 Z AQUILAE—												
	2845.6	12.9	Gi,	2869.5	11.5	Gi,	2882.4	10.0	Gi,	2884.8	9.6	M,
	2897.5	9.5	Gi,	2898.7	9.4	Pt,	2906.8	9.5	M.			
200938 RS CYGNI—												
	2820.3	8.8	Ch,	2842.3	8.8	Ch,	2844.4	8.0	L,	2855.4	8.1	Pe,
	2857.4	7.8	L,	2862.8	8.4	M,	2868.2	7.6	Ch,	2869.4	7.9	L,
	2869.7	7.6	Pt,	2883.4	7.7	L,	2893.4	7.5	L,	2898.7	7.4	Pt,
	2902.6	7.2	L,	2905.8	8.3	M,	2911.6	7.5	Ya.			
200916 R SAGITTAE—												
	2862.8	8.7	M,	2895.7	9.0	M,	2907.6	9.1	Gi,	2911.7	10.0	Ya.
201008 R DELPHINI—												
	2848.5	13.5	L,	2864.4	<12.3	L,	2870.6	12.8	L,	2880.5	12.4	L,
	2894.4	12.5	L,	2900.7	12.6	Pt,	2902.8	9.7	M.			

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
201130 SX CYGNI—												
	2900.6	13.6	B.									
201121 RT CAPRICORNI—												
	2858.5	6.4	L,	2869.5	6.6	L,	2880.5	6.6	L,	2893.5	6.6	L,
	2910.6	7.8	Ya.									
201139 RT SAGITTARII—												
	2871.7	9.3	Pt.									
201437a P CYGNI—												
	2820.3	5.0	Ch,	2842.3	5.1	Ch.						
201647 U CYGNI—												
	2844.5	9.0	Gi,	2857.4	9.1	Gi,	2866.4	11.0	Pe,	2867.7	8.6	Mu,
	2867.7	9.7	M,	2869.4	9.1	Gi,	2869.7	10.0	Pt,	2879.6	10.0	Ro,
	2883.5	9.4	Gi,	2881.6	10.0	Ro,	2888.7	9.8	M,	2894.5	10.2	Ro,
	2895.6	9.6	M,	2898.7	10.5	Pt,	2899.5	10.8	Ro,	2901.4	9.7	Gi,
	2902.5	11.0	Ro,	2903.5	11.0	Ro,	2905.7	11.1	Ps,	2907.6	<9.8	Jd,
	2910.5	11.2	Ro,	2910.7	10.8	Ya.						
202539 RW CYGNI—												
	2862.8	9.0	M,	2905.8	8.3	M.						
202622 RU CAPRICORNI—												
	2857.5	11.2	Gi,	2870.5	9.9	Gi,	2882.5	9.5	Gi,	2898.6	9.2	Gi.
202817 Z DELPHINI—												
	2869.7	9.8	Pt,	2878.8	9.8	M,	2898.7	10.1	Pt,	2901.6	10.2	B.
	2905.8	10.2	M.									
202954 ST CYGNI—												
	2873.7	11.9	Pt,	2881.7	<11.7	M.						
202946 SZ CYGNI—												
	2867.7	10.0	M,	2905.8	9.2	M,	2907.6	9.3	Cl.			
203226 V VULPECULAE—												
	2868.8	9.1	M,	2871.8	8.8	Pt,	2898.7	8.7	Pt,	2905.8	8.7	M.
203847 V CYGNI—												
	2820.3	<10.9	Ch,	2844.5	8.7	Gi,	2857.4	8.4	Gi,	2868.2	9.3	Ch,
	2869.4	8.1	Gi,	2881.7	9.0	M,	2884.4	8.0	Gi,	2888.7	8.9	M,
	2895.6	8.5	M,	2901.4	7.8	Gi,	2903.6	8.0	B,	2920.8	9.4	M.
203816 S DELPHINI—												
	2870.8	9.7	M,	2900.7	11.3	V,	2902.8	10.6	M,	2910.6	11.0	Cl.
203905 Y AQUARII—												
	2884.8	9.6	M,	2898.8	9.8	M.						
204016 T DELPHINI—												
	2866.4	<12.0	Pe,	2866.8	<13.3	Wf,	2870.8	<12.0	M,	2879.9	<14.0	Wf,
	2884.8	<14.0	Wf,	2894.9	<14.0	Wf,	2901.6	<13.5	B,	2901.9	<14.0	Wf,
	2908.9	<14.0	Wf.									
204104 W AQUARII—												
	2849.5	11.8	Gi,	2853.4	11.8	L,	2865.5	12.3	Gi,	2866.4	12.3	L,
	2872.8	12.0	M,	2877.6	12.1	Gi,	2880.4	12.5	L,	2887.6	12.4	Gi,
	2899.4	12.8	L.									
204215 U CAPRICORNI—												
	2845.5	13.2	Gi,	2870.5	11.2	Gi,	2882.5	11.1	Gi,	2898.6	11.3	Gi.
204318 V DELPHINI—												
	2853.5	<14.3	Gi,	2866.4	<12.5	Gi,	2876.5	<14.3	Gi,	2886.8	<12.5	M.
	2899.4	<13.9	Gi.									
204405 T AQUARII—												
	2842.3	<11.0	Ch,	2871.8	<11.5	M,	2898.8	12.5	M,	2903.7	12.0	Ca.
204846 RZ CYGNI—												
	2853.5	13.4	Gi,	2865.5	12.8	Gi,	2875.4	12.2	Gi,	2884.8	9.2	M,
	2885.4	11.6	Gi,	2888.6	9.0	M,	2898.4	11.5	Gi,	2902.8	10.4	M.
205030a UX CYGNI—												
	2868.8	11.6	M.									
205017 X DELPHINI—												
	2901.7	13.1	B.									
205923 R VULPECULAE—												
	2845.5	13.1	Gi,	2857.5	11.7	Gi,	2867.7	10.2	M,	2869.4	9.8	Gi,

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
205923 R VULPECULAE—Continued.												
	2873.7	10.0	Pt,	2881.5	9.2	Gi,	2897.5	8.7	Gi,	2898.7	8.8	Pt,
	2902.6	9.0	O,	2902.8	9.0	M.						
210129 TW CYGNI—												
	2870.8	<12.5	M.									
210116 RS CAPRICORNI—												
	2878.8	9.0	M,	2910.6	8.3	Ya.						
210124 V CAPRICORNI—												
	2857.5	<12.5	Gi,	2870.5	<12.7	Gi	2882.6	<12.7	Gi.			
210221 X CAPRICORNI—												
	2857.5	11.7	Gi,	2870.5	12.1	Gi,	2882.5	12.7	Gi.			
210382 X CEPHEI—												
	2910.6	11.8	M.									
210504 RS AQUARII—												
	2854.4	11.2	L,	2866.4	12.1	L,	2880.4	12.6	L,	2899.4	<13.3	L,
	2910.8	<11.5	M.									
210516 Z CAPRICORNI—												
	2884.8	11.4	M,	2906.8	10.5	M.						
210868 T CEPHEI—												
	2813.4	6.6	Ch,	2842.3	7.6	Ch,	2844.4	6.6	L,	2857.4	6.7	L,
	2862.6	7.9	O,	2864.8	7.9	M,	2865.6	8.0	O,	2865.6	7.5	O.
	2867.5	7.1	L,	2873.7	7.9	Pt,	2877.4	7.5	L,	2885.4	7.5	L,
	2892.6	8.8	O,	2898.7	8.9	Pt,	2900.6	8.8	L,	2902.5	8.9	Cg.
	2905.8	9.0	M,	2906.6	8.3	Ca,	2906.6	9.2	O,	2911.6	8.8	Ya.
211614 X PEGASI—												
	2848.5	12.2	Gi,	2862.5	12.5	Gi,	2872.5	12.9	Gi,	2884.5	12.7	Gi,
	2898.5	11.7	Gi,	2916.8	10.8	M.						
211615 T CAPRICORNI—												
	2886.8	12.2	M,	2910.6	<11.3	Ya.						
212030 S MICROSCOPII—												
	2898.6	10.4	Bh.									
213814 Y CAPRICORNI—												
	2886.8	<12.0	M.									
213244 W CYGNI—												
	2844.4	9.9	L,	2854.4	5.9	L,	2857.4	5.9	L,	2867.5	5.9	L,
	2869.4	5.8	Pe,	2873.4	5.9	Be,	2873.4	5.9	L,	2880.4	5.9	L,
	2893.4	6.2	L,	2898.4	6.3	L.						
213678 S CEPHEI—												
	2844.5	8.2	Gi,	2858.4	8.3	Gi,	2864.8	8.4	M.	2873.5	8.3	Gi,
	2873.7	8.0	Pt,	2888.4	8.2	Gi,	2895.6	8.3	M,	2900.7	8.0	Pt,
	2901.5	8.1	Gi.									
213753 RU CYGNI—												
	2864.8	8.4	M,	2910.8	8.5	M.						
213843 SS CYGNI—												
	2813.4	8.2	Ch,	2820.3	<9.6	Ch,	2836.7	11.8	Du,	2840.6	11.8	Du,
	2843.6	11.6	L,	2844.5	11.8	Gi.	2845.4	11.9	Pe,	2845.5	11.8	Gi,
	2846.4	11.7	L,	2848.4	11.8	Gi,	2849.4	11.8	Gi,	2850.5	11.8	Gi,
	2851.4	11.8	Gi,	2852.4	12.0	Pe,	2852.5	11.7	L,	2853.4	11.7	L,
	2853.5	11.8	Gi,	2854.4	11.5	L,	2854.5	11.8	Gi,	2857.4	11.6	L,
	2857.5	11.8	Gi,	2858.4	11.8	Gi,	2858.6	11.9	L,	2860.7	11.9	Wf,
	2862.4	11.7	Gi,	2863.4	11.8	Gi,	2863.4	11.5	L,	2864.4	11.7	Gi,
	2864.4	11.5	L,	2864.7	11.8	Pt,	2865.3	12.0	Pe,	2865.4	11.6	L,
	2865.5	11.8	Gi,	2866.2	11.6	Ch,	2866.4	11.7	Gi.	2866.4	11.5	L,
	2866.4	12.0	Pe,	2866.8	11.9	Wf,	2867.4	11.8	Gi,	2867.4	11.3	L,
	2867.7	<10.9	Mu,	2867.7	11.5	Pt,	2867.8	11.8	Wf,	2868.5	11.6	Gi,
	2869.4	11.8	Gi,	2869.4	11.7	L,	2869.7	11.8	Pt,	2870.5	11.8	Gi,
	2870.6	11.5	L,	2870.8	11.5	M,	2870.8	11.9	Pt,	2871.4	11.8	Gi,
	2871.5	11.7	L,	2871.8	11.4	M,	2871.8	11.8	Pt,	2872.4	11.8	Gi,
	2872.4	11.5	L,	2872.7	11.4	M,	2873.4	11.8	Ch,	2873.4	11.5	L.
	2873.6	11.9	Pt,	2873.8	11.4	M,	2874.6	<10.9	Ya,	2875.1	10.0	Jk,
	2875.4	8.9	Gi,	2875.4	8.6	L,	2875.6	8.6	Ro,	2876.5	8.5	Gi,
	2877.4	8.3	Be,	2877.4	8.7	Gi,	2877.4	8.4	L,	2878.7	8.6	Pt,

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—Continued.												
	2878.7	9.0	Wf,	2878.8	8.7	M,	2879.6	8.8	Ro,	2879.7	8.6	Pt,
	2879.8	8.7	Wf,	2880.4	9.1	L,	2880.7	8.8	Pt,	2880.7	9.2	Wf,
	2881.4	9.5	Gi,	2881.6	9.6	Ro,	2881.7	9.4	M,	2881.8	9.5	Wf,
	2882.4	10.1	Bc,	2882.4	9.8	Gi,	2882.4	9.8	L,	2882.7	10.0	M,
	2882.7	9.8	Pc,	2882.7	10.2	Wf,	2882.8	10.0	Pt,	2883.4	10.3	Gi,
	2883.4	9.9	L,	2883.9	10.4	Wf,	2884.4	11.1	Gi,	2884.4	10.2	L,
	2884.7	10.9	Wf,	2884.8	10.6	M,	2885.4	11.5	Gi,	2885.4	10.8	L,
	2885.5	11.2	Rk,	2885.9	11.1	Wf,	2886.4	11.6	Gi,	2886.6	11.1	L,
	2886.8	11.5	M,	2886.8	11.6	Pt,	2886.8	11.7	Wf,	2887.4	11.8	Gi,
	2887.6	<11.8	Gd,	2887.7	11.9	Wf,	2888.4	11.9	Gi,	2888.4	11.4	L,
	2888.8	11.8	Wf,	2889.7	11.9	Wf,	2890.8	11.7	Wf,	2891.4	11.5	L,
	2891.6	11.6	B,	2891.8	11.9	Wf,	2892.4	11.6	L,	2892.6	11.5	B,
	2892.7	11.7	Wf,	2893.4	11.8	L,	2893.6	11.2	Pw,	2893.9	11.6	Wf,
	2894.4	11.6	L,	2894.5	11.8	Ro,	2894.9	11.6	Wf,	2895.4	11.7	L,
	2895.8	11.8	Wf,	2896.4	11.9	Rk,	2896.6	11.7	B,	2896.7	11.5	Ya,
	2897.5	11.8	Gi,	2897.6	11.7	B,	2897.7	11.8	Pt,	2897.9	11.8	Wf,
	2898.4	11.8	Gi,	2898.4	11.7	L,	2898.7	11.9	Pt,	2898.8	12.0	M,
	2899.4	11.8	Gi,	2899.5	11.8	Ro,	2899.9	11.5	Wf,	2900.4	11.8	Gi,
	2900.6	11.7	B,	2900.6	11.9	L,	2900.7	11.9	Pt,	2900.7	<11.3	V,
	2900.9	11.8	Wf,	2901.4	11.8	Gi,	2801.4	11.6	L,	2901.4	11.7	Rk,
	2901.8	11.5	Pt,	2901.9	11.8	Wf,	2902.4	11.8	Gi,	2902.5	11.4	Ro,
	2902.6	11.9	L,	2902.8	12.0	M,	2902.8	11.9	Wf,	2903.5	11.4	Ro,
	2903.6	11.5	Ca,	2903.6	11.1	Cl,	2903.6	11.7	B,	2903.8	11.8	Wf,
	2904.8	12.0	Wf,	2905.6	11.9	Cl,	2905.6	<10.5	O,	2905.7	11.9	Wf,
	2905.8	12.0	M,	2905.8	11.7	Pt,	2906.6	11.7	B,	2906.6	11.7	Ca,
	2906.6	<11.8	Jd,	2906.7	11.7	Pt,	2907.6	11.0	Cl,	2907.6	<11.0	Pc,
	2907.7	11.8	Wf,	2908.8	11.5	Pt,	2908.9	11.7	Wf,	2909.7	11.7	Pt,
	2910.6	<10.5	O,	2910.6	11.8	Ps,	2910.7	11.8	Wf,	2910.7	11.3	Ya,
	2910.8	12.0	M,	2911.6	11.8	Jd,	2911.6	<11.1	Pc,	2911.8	11.9	Wf,
	2912.8	12.1	Wf,	2913.8	12.0	Wf,	2914.7	11.9	Pt,	2916.8	11.6	Pt.
213937 RV CYGNI—												
	2864.8	8.4	M,	2910.8	8.5	M.						
214024 RR PEGASI—												
	2871.8	9.6	Pt,	2898.7	11.4	Pt.						
215605 V PEGASI—												
	2898.7	11.8	M.									
220412 T PEGASI—												
	2848.5	9.4	Gi,	2858.5	9.5	L,	2862.5	9.3	Gi,	2869.5	9.9	L,
	2871.8	10.3	M,	2872.6	10.2	Gi,	2884.4	10.6	L,	2885.5	10.8	Gi,
	2899.4	11.1	L,	2905.8	11.0	M.						
220613 Y PEGASI—												
	2848.5	<13.4	Gi,	2871.5	<13.4	Gi,	2881.6	<13.4	Gi,	2882.7	<12.1	M,
	2898.8	<12.1	M,	2899.5	<13.4	Gi.						
220714 RS PEGASI—												
	2848.5	9.4	Gi,	2862.5	9.1	Gi,	2872.6	9.3	Gi,	2882.7	9.9	M.
	2885.5	9.3	Gi,	2898.7	9.8	M,	2899.5	9.4	Gi.			
222439 S LACERTAE—												
	2845.5	13.0	Gi,	2848.5	13.1	L,	2857.6	12.5	Gi,	2866.5	12.3	L,
	2869.4	12.0	Gi,	2880.4	11.6	L,	2881.5	10.7	Gi,	2893.5	10.4	L,
	2897.6	10.2	Gi.									
223841 R LACERTAE—												
	2845.6	14.0	Gi,	2848.5	<14.0	L,	2857.6	13.9	Gi,	2866.5	<13.0	L,
	2869.5	13.7	Gi,	2880.4	12.9	L,	2881.5	12.6	Gi,	2893.5	10.3	L.
	2897.6	9.9	Gi.	2902.6	9.5	L.						
225914 RW PEGASI—												
	2898.7	<12.1	M.									
230110 R PEGASI—												
	2871.8	<1.5	M,	2902.8	10.4	M.						
230759 V CASSIOPEIAE—												
	2852.4	8.4	Pc,	2853.6	7.8	Gi,	2857.4	8.2	Pc,	2865.4	7.6	Pc,
	2865.5	7.7	Gi,	2867.7	8.0	Mu,	2871.8	7.3	M,	2871.8	7.5	Pt.

VARIABLE STAR OBSERVATIONS, June 20 to August 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
230759 V CASSIOPEIAE—Continued.								
	2875.5	7.8 Gi,	2885.5	8.1 Gi,	2892.7	9.2 Pt,	2898.6	9.4 O,
	2899.5	9.1 Gi,	2900.7	9.0 V,	2903.5	9.8 Ro,	2906.7	9.7 M,
	2910.5	10.0 Ro.						
231425 W PEGASI—								
	2858.5	11.3 L,	2869.5	11.6 L,	2871.8	11.5 M,	2882.6	11.7 L,
	2898.8	12.4 M,	2899.4	11.8 L.				
231508 S PEGASI—								
	2871.8	10.5 Pt,	2908.8	8.0 Pt.				
233335 ST ANDROMEDAE—								
	2853.4	10.4 Ch,	2871.8	10.8 M,	2871.8	10.7 Pt,	2878.8	10.8 Wf,
	2884.8	10.8 Wf,	2895.8	10.8 Wf,	2900.7	11.0 Pt,	2902.8	11.1 Wf,
	2910.7	11.1 Wf,	2910.8	11.2 M.				
233815 R AQUARII—								
	2853.4	9.9 Ch,	2886.8	10.1 Pt,	2903.7	10.3 Ca,	2905.8	10.4 Pt.
235053 RR CASSIOPEIAE—								
	2853.4	11.4 Gi,	2865.5	11.6 Gi,	2875.5	11.6 Gi,	2885.6	12.1 Gi,
	2901.5	13.3 Gi.						
235209 V CETI—								
	2870.6	11.4 L,	2884.6	9.3 L,	2900.6	8.6 L,	2905.8	9.1 Pt.
235350 R CASSIOPEIAE—								
	2849.5	12.0 Gi,	2862.6	11.2 Gi,	2872.5	11.3 Gi,	2878.8	12.0 M,
	2884.5	10.8 Gi,	2899.5	10.4 Gi,	2920.8<11.0 M.			
233956 Z CASSIOPEIAE—								
	2867.8<13.4 Wf,		2879.8<13.4 Wf,		2885.9<13.4 Wf,		2894.9<13.4 Wf,	
	2902.8<13.4 Wf,		2910.7<13.4 Wf.					
235525 Z PEGASI—								
	2871.8	9.0 Pt,	2886.8	9.8 M,	2900.7	10.5 Pt,	2906.6	10.5 O,
	2906.8	10.5 M.						
235855 Y CASSIOPEIAE—								
	2849.5<12.8 Gi,		2884.5<12.8 Gi.					
235939 SV ANDROMEDAE—								
	2900.7	12.5 Pt.						

Total Observations: 2,249. Stars Observed: 270. Observers: 35.

June 0 = 2422841 July 0 = 2422871 August 0 = 2422902

The members disbanded on Sunday, most of them returning to New York along the Hudson by automobiles.

The following members and their friends were present: Mr. and Mrs. Olcott, Mr. and Mrs. Pickering, Mr. and Mrs. Waldo, Mr. and Mrs. Yalden, Misses Cannon, Furness, Hawes, Swartz, and Messrs. Campbell, Godfrey, Perry, Potter, Hunter, McAteer, Saunders, Murray, and Macaughey.

Word has been received from Mr. Eaton that he is comfortably established at Banor, North Wales. He has visited Mr. Brook, Director of the Variable Star Section of the B. A. A., who received him most courteously, and showed him every attention. In a letter to the President he takes occasion to express to each and every contributor to the purse which was presented to him on the eve of his departure for England his most profound appreciation and sincerest thanks.

The Association, through the generosity of Mrs. Charles A. Post of Bayport, L. I., has recently come into the possession of the splendidly equipped observatory of the late Charles A. Post. Included in the outfit is a 6-inch Brashear telescope, several photographic cameras, and a transit telescope, besides numerous books and lantern slides. This is to be kept together as a Memorial to Mr. Post at some place yet to be decided upon by the Council. Mrs. Post has been recently elected a Patron of the Association.

The following have been elected to active membership in the Association:

G. F. Townsend, Fort Worth, Texas
G. C. Olcott, Chicago, Ill.
W. D. MacPherson, Framingham, Mass.
E. M. Stanton, Chicago, Ill.
J. M. F. Partello, Garrett Park, Md.
J. C. Packard, Brookline, Mass.
U. G. Schwennsen, St. Paul, Minn.
W. F. H. Waterfield, Nakusp, B. C.
G. E. Buscombe, Jr., Vancouver, B. C.
E. F. Sawyer, Boston, Mass.
J. H. Skaggs, Oakland, Cal.
H. Thew, Santa Monica, Cal.
A. C. White, Litchfield, Conn.
W. F. Brown, High Point, N. C.

The Association has received a gift of books for the Library from the Misses Burbeck and Hagen Charts from Mr. E. F. Sawyer.

Mr. W. J. Luyten, our member from Holland, is to spend the next year at the Lick Observatory.

It is Mr. Janczewski, not Mr. de Perrot as incorrectly stated in the previous report, who has gone to Cracow.

Mrs. Paraskevopoulos, formerly Miss Dorothy Block, is leaving for Athens, Greece. Dr. Paraskevopoulos is a member of the staff of the Observatory there.

The observation by Miss Jenkins on the rise of SS Cygni, the only one reported, is another example of the advantage of co-operation of observers in different parts of the world. The rise occurred unfavorably for western observers.

The following is a list of all observers who contributed to this double report, which includes the first reports of Messrs. Aurino, Allen, Hudson, and Proctor: Messrs. Allen "Ap," Aurino "Au," Bemporad "Bp," Benini "Be," Bouton "B," Bunch "Bh," Carr "Ca," Chandra "Ch," Clement "Cl," Miss Clough "Cg," Dunham "Du," Ginori "Gi," Godfrey "Gd," Hudson "Hc," Miss Jenkins "Jk," Jordan "Jd," Kaster "Ka," Lacchini "L," Lacy "Lc," McAteer "M," Merton "Mt," Mundt "Mu," Olcott "O," Mrs. Olcott "Mo," Peltier "Pt," de Perrot "Pe," Peters "Ps," Proctor "Pc," Reesinck "Rk," Rhorer "Ro," Suter "Su," Vrooman "V," Waterfield "Wf," Watson "Pw," and Yalden "Ya."

ARVILLE D. WALKER, Recording Secretary.

COMET AND ASTEROID NOTES.

All the comets which have been seen during the summer are now either very far away or far south, so that they can no longer be followed by northern observers. All but Winnecke's are now beyond the reach of small telescopes.

Reference to the diagram in the June-July number of POPULAR ASTRONOMY will show that Winnecke's comet is now fully twice as far away from the earth as it was when picked up in April. No ephemeris of it, extending beyond July 20 is at hand.

It is possible that Encke's periodic comet may have been seen by southern observers during the past month, but no reports have come of its discovery. Its

position during October will be along an arc extending from the eastern part of the constellation Scorpio into Sagittarius, as shown by the following ephemeris, which is given in the March number of *The Observatory*.

EPHEMERIS OF ENCKE'S COMET.

	R. A. h m s	Dec. ° ′
Oct. 1	17 01 00	—30 43
9	27 54	—30 29
17	17 51 24	—30 05

The accompanying diagrams of the orbits of the comets discovered by Taylor and Skjellerup last December and by Reid on March 13, will show to the reader at a glance why they could be seen so well about the time they were

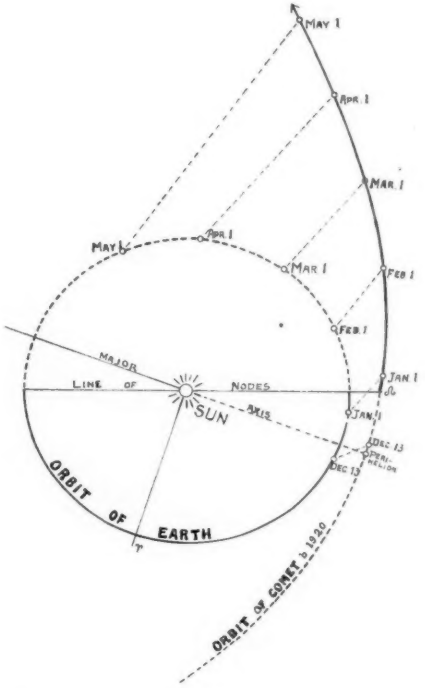


DIAGRAM SHOWING THE ORBITS OF THE TAYLOR-SKJELLERUP COMET *b* 1920 AND THE EARTH.

discovered and why they are now beyond reach. Both comets came up from below the plane of the ecliptic; the former was discovered before and the latter just after it passed through that plane. The Taylor-Skjellerup comet was moving direct, i. e., in approximately the same direction with the movement of the planets around the sun. Reid's comet was moving retrograde, i. e. roughly

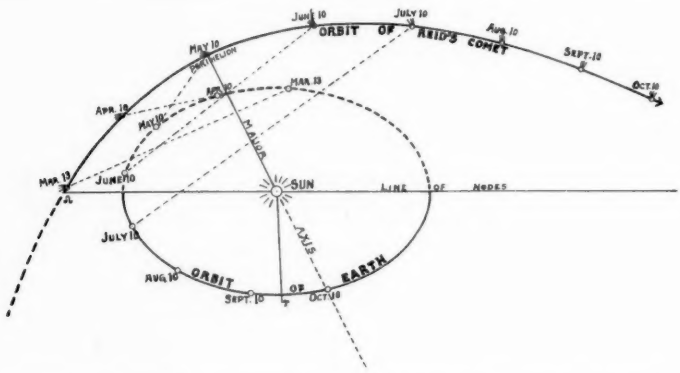


DIAGRAM SHOWING THE ORBIT OF REID'S COMET *a* 1921 AND THE EARTH

opposite to planetary motion. It was best situated in the latter part of April when it passed nearest to the earth. It was for some days so nearly over the earth, with reference to the equatorial plane, that it became a circumpolar object, not setting night or day. Now it is going down to the ecliptic but will for a long time remain above the equator.

ADDED NOTE:—As we go to press we learn that Encke's comet was found by Messrs. Skjellerup and Reid at Cape Town on July 27 at $5^h\ 15^m$ G. M. T. Its position then was R.A $10^h\ 08^m\ 11^s$, Dec. 4° 58′ N. Encke's comet will be known at this apparition as 1921*d*.

The Pons-Winnecke Comet.—At the May meeting of the Royal Astronomical Society (London), Dr. A. C. D. Crommelin, in discussing a recent photograph of the Pons-Winnecke comet, said: "The latest orbit places the perihelion about 2 million miles outside the earth's orbit. The perturbations of Jupiter have been enormous during the last revolution. They are the largest on record for this comet, having increased the perihelion distance by about 5 million miles during the revolution." This is an interesting fact for teachers of astronomy to note.

Elements of Reid's Comet *a* 1921.—The following elements are given in the *Lick Observatory Bulletin*, Number 331. They were calculated by S. Einarsson and W. F. Meyer, and were based upon observations on the dates March 14, April 2 and 21. An observation by Mr. Meyer on May 13 was represented by these elements with the following residuals:

$$(O-C)\quad \Delta\alpha \cos\delta = +8^s \quad \Delta\delta = -5'.$$

ELEMENTS OF REID'S COMET.

$$\left.\begin{aligned} \omega &= 64^\circ\ 24'\ 46'' \\ \Omega &= 268^\circ\ 17'\ 57'' \\ i &= 132^\circ\ 05'\ 40'' \end{aligned}\right\} 1921.0$$

$T = 1921$ May 9.91876 G. M. T.

$q = 1.00895$

Bright Object near Sun.—The following telegram has been received from Professor W. W. Campbell, Director of the Lick Observatory:

"Starlike object certainly brighter than Venus three degrees east one degree south of Sun seen seven minutes before and at sunset by naked eye five observers set behind low clouds unquestionably celestial object chances favor nucleus bright comet less probably nova."

Harvard College Observatory Bulletin 757.

Cambridge, Mass., U. S. A., August 9, 1921.

No further word has been received concerning this object.

Recently Named Minor Planets.—In the *Astronomische Nachrichten* No. 5116, Professor Max Wolf gives the following list of names of asteroids discovered by him. It may be noticed that seven of them are drawn from the names of astronomers and benefactors of astronomy.

No.	Preliminary Designation	Name	No.	Preliminary Designation	Name
707	(1910 LD)	Steina	834	(1916 AD)	Burnhamia
733	(1912 PF)	Mocia	836	(1916 AF)	Jole
800	(1915 WP)	Kresmannia	870	(1917 BX)	Manto
802	(1915 WR)	Epyaxa	880	(1917 CK)	Herba
810	(1915 XQ)	Atossa	883	(1917 CP)	Matterania
813	(1915 YR)	Baumeia	888	(1918 DC)	Parysatis
822	(1916 ZD)	Lalage	901	(1918 EE)	Brunsia
823	(1916 ZG)	Sisigambis	907	(1918 EU)	Barnardiana
831	(1916 AA)	Stateira			

COMMUNICATIONS.

A Bright Meteor.—At 8:20 p. m., July 13, an unusually bright meteor passed over Baltimore. Its course was E. to W. about 40° S of the zenith. It was attended by a noduled tail about 3° in length. Its light was a brilliant green. The sky was hazy. Emerging from the eastward haze its visibility did not exceed 10 seconds before it was lost in the haze to the westward. It was probably a member of the July 13-14 epoch which was discussed by Professor Kirkwood in his "Meteoric Astronomy."

W. E. Glanville.

Holy Innocents' Rectory, Baltimore, Md., 1921, July 15.

A Bright Meteor—On the evening of August 1, 1921, I was aboard the Panama R. R. Steamship, Colon, just leaving the harbor of Port-au-Prince, Haiti.

In the path of the Sun at an elevation of 45° above the western horizon a light appeared that at first seemed to be a very bright star just becoming visible. The apparent diameter of this light continued increasing until it equalled about six inches. It was clearly reflected in the water, and it appeared to have a wavering motion giving an impression similar to that of watching the head light of an approaching locomotive. The time from the first visibility up to this point was probably one minute, certainly no longer.

The body then changed its course and traveled through a perpendicular course, and with another change of a few degrees to the south, it set behind

the horizon, coloring the clouds faintly and leaving a glow in the sky similar to a miniature sunset. The time consumed in its perpendicular course from an elevation of 45° was about two minutes.

M. L. FITZPATRICK.

A Correction.—Since the publication of my article on The "Quantum" Equation in the Solar System, in the June-July number of Popular Astronomy, Professor Comstock, of Washburn Observatory, has kindly called my attention to the fact that the expression R^3/T, which is constant only for an individual orbit, is incapable of substitution in the general equation for the kinetic energy of orbital motion, and hence that the expression $E=k/T$ does not apply to the planets of the solar system.

FERNANDO SANFORD.

GENERAL NOTES.

Prof. H. C. Plummer, F. R. S., has been appointed Professor of Mathematics at the Ordnance College, Woolwich. (*The Observatory*, August 1921.)

Maynard F. Jordan, A. M., (University of Maine), has been appointed Austin Teaching Fellow at Harvard University for the year 1921-22.

Prof. P. Guthnick has been appointed director of the Babelsberg Observatory in succession to the late Herman Struve. —(*The Observatory*, July 1921.)

Col. John Herschel, youngest son of the astronomer Sir John Herschel, died on May 31, 1921, in his 84th year. He was for nearly 30 years on the Trigonometrical Survey of India. He observed the eclipses of 1868 and 1871.

Father J. G. Hagen's volume entitled "Die Veränderlichen Sterne," now finished, was so highly valued by the University of Bonn, his former Alma Mater, that it conferred upon the author the title of Honorary Doctor of Philosophy.

Professor William F. Rigge, on August 28, 1921, completed his twenty-fifth year of continuous service as professor of astronomy and physics at the Creighton University, Omaha, Neb.

The Diameters of Arcturus and Antares.—In the August number of Publications of the Astronomical Society of the Pacific, Mr. Pease of the Mt. Wilson Observatory gives the angular diameter of Arcturus as 0."022 and of Antares as 0."040. If the parallax of the former is 0."095 and of the latter

0."0085 the diameters are 21,000,000 and 430,000,000 miles respectively. The observations were made by the interferometer method with the 100-inch Hooker telescope.

Rotation of Four Spiral Nebulae.—In the same number of the Publications of the A. S. P. Mr. A. van Maanen reports that by comparison of plates taken with the 60-inch reflector of the Mt. Wilson Observatory and the Crossley reflector of the Lick Observatory he finds evidences of rotation in four spiral nebulae, M. 101, M 33, M 51, and M 81, which correspond to periods of rotation of 85,000, 160,000, 45,000 and 58,000 years respectively.

Prof. Judson Boardman Coit, a member of the faculty of the College of Liberal Arts of Boston University, died on July 26, 1921, at a private sanitarium in Melrose. He was born in Central square, Oswego County, N. Y., on June 5, 1849, the son of James J. and Miriam (Owen) Coit. In 1875 he was graduated from Syracuse University with an A. B. degree, in 1878 received an A.M., and in 1881 a Ph.D.

From 1875 to 1879, he was professor of mathematics at Dickinson Seminary, in Williamsport, Pa., and immediately afterward he was a student-assistant in the observatory at Ann Arbor for one year. For the two years following, Professor Coit taught mathematics at the Central High School in Cleveland, O.

In 1882 he came to Boston to become assistant professor of mathematics and astronomy at Boston University, which position he held until 1884, when he became the head of these departments. From 1911 to 1912 he was acting dean of the Graduate School. Since 1915 he had confined his work to the department of astronomy.

A Great Telescope for Seattle, Washington.—According to a clipping sent us from the July 24, 1921, issue of the *Seattle Post-Intelligencer*, the city of Seattle, Washington, is to have in the near future the "largest stellar telescope in the world and the greatest astronomical observatory." We have no authoritative information in regard to the matter, but according to the "clipping" Mr. Charles S. Frye, Seattle capitalist, will build and endow the observatory. He, at the date of the "clipping," was in Europe studying the architecture of English and continental observatories and expected on his return to choose the site and decide the design of the dome to house the big telescope. The telescope is to be a reflector with a mirror of 120 inches diameter, exceeding the diameter of the Hooker telescope at Mount Wilson by 20 inches. The glass disk for the mirror is to be cast and ground by T. S. H. Shearman, a Canadian astronomer and telescope builder, who has invented a new and secret process of annealing optical glass, which he believes will vastly shorten the time required for making the new mirror.

Super-Cepheids.—The following remarks by Dr. Lockyer are abstracted from the account of the June meeting of the Royal Astronomical Society given in *The Observatory* for July 1921:

"In the evolution of the stars there is a group about spectral type A2 which

is rather scarce in the heavens; α Cygni is the typical star and the Harvard classification is A2p. In 1570 stars examined at South Kensington and Sidmouth we have only found four like α Cygni. An important stage of temperature or ionisation is indicated by the strength of the enhanced lines. The star φ Cassiopeiae has been found to be intermediate in type between α and γ Cygni. Hydrogen, enhanced magnesium, iron and silicon are progressively stronger as you pass from γ Cygni through φ Cassiopeiae to α Cygni; enhanced titanium, arc lines of iron, calcium, silicon and nickel become progressively stronger in the reverse direction; enhanced strontium is strongest in φ Cassiopeiae. Other stars akin to this group of stars are ε Aurigae, α Leporis, α Carinae, θ Scorpii, ι Scorpii, 34 and 45 Draconis. These are all giants, and Prof. Russell recently at Sidmouth told us that our method had picked out numerous stars which they had termed super-Cepheids. In this connection it is interesting to note that the spectra of both δ Cephei and η Aquilae are sometimes rather like φ Cassiopeiae and something like γ Cassiopeiae. The dwarf star α Canis Minoris, which is equivalent in temperature to the giant ε Aurigae, has its enhanced lines far less prominent. These facts may have some application to the history of the early stages of novae."

In answer to questions Dr. Lockyer said that a super-Cepheid is a giant star higher in temperature than a Cepheid. Its spectrum resembles that of a Cepheid but it may not vary in brightness. Only 1 in 100 of the stars is a giant. The great majority are dwarfs.

Orbit of the Binary Star Σ554=80 Tauri.—In the *Monthly Notices* of the Royal Astronomical Society, Vol. LXXXI No. 7, May 1921, Mr. W. H. van den Bos gives elements of the binary star Σ554, based upon all the available observations from 1831 to 1921. In that time the star has completed more than three fourths of a revolution, although the remaining one fourth will require about 60 years. The period is about 150 years. The calculator has derived two sets of elements, the small differences between which indicate to some extent the degree of uncertainty of the results obtained.

Elements of Σ554=80 Tauri.

	A	B
P	148.3 years	150.2 years
e	0.790	0.728
T	1888.30	1886.84
a	1″.036	1″.060
i	±71°.0	±73°.7
☊	8.88	11°.80
ω	157°.92	162°.38
$a/P^{2/3}$	0″.0370	0″.0376

For the next hundred years this double will be an easy pair to observe with large telescopes, the distance increasing from 1″ to 1.″7, then decreasing by about the same amount. The magnitudes of the components are 6.5 and 9.0. With the parallax 0″.027 adopted by Hertzprung the sum of the masses of the two stars comes out 2.57 times the mass of the sun.

An Astronomer's Life in Russia.—The following extracts translated from a letter written by a prominent Russian astronomer, recently received by Professor Frost, of the Yerkes Observatory, will be of great interest to many

readers of POPULAR ASTRONOMY, especially to those who met the distinguished astronomer when he was in America a number of years ago.

"Here we have passed through hard times. I might say that we are still passing through them, except in so far as patience and experience have supported us in bearing with the difficulties. 1918 was a particularly difficult year and several of my colleagues of the Academy were unable to bear the lack of food and died. At Pulkovo it was not so bad, because each of the astronomers had a vegetable garden of about 1000 square meters in area, which we cultivated with our own hands and produced enough potatoes, carrots and other vegetables to supply us for the whole year. I am very glad that my strength, in spite of my age of 67 years, permitted me to bear my part in this work. In every respect we have all become Robinson Crusoes because we are compelled to know how to do everything ourselves—to repair clothes, boots, and everything that wears out, inasmuch as it is hardly possible to buy anything new, for nothing is to be had.

"Money has hardly any value and the black bread, which in 1917 still cost from 2 to 4 kopecks per pound, is now 4000 rubles and in some places as high as 18,000 rubles. In the beginning of 1921, we could still buy a pair of boots for 300,000 rubles, but now they are not to be had at all. For the most part, people are dressed in rags. A few other examples: a goat costs about a million rubles; a cow, ten million; a glass of milk one thousand rubles.

"The worst thing is the cold of winter, for wood is lacking for heating. The people at our observatory have used the trees of the park, which protected us from dust and snow storms. Now there is little left of it and we are looking forward to the coming winter with small joy.

"But science has been a great consolation in all this. We work here as much as possible, but the publication of manuscripts is exceedingly difficult. Three of my papers have not been able to appear during the last two years. The lack of photographic plates and chemicals has hindered the activity of our astronomers. There is also a lack of lighting in winter and we have to pass the evenings in darkness. It is said that life in all parts of the world has become more difficult, but it appears that culture has not fallen so low in other countries as it has with us.

"On the 12th of November 1917 a battle was fought on the grounds of the observatory of Pulkovo between the Cossacks and the Communists, and in October 1919 a battle between the Communists and the White Russians lasted without interruption for a whole week. Fate was very kind to the observatory, however, and the buildings suffered very little in spite of the fact that the projectiles hit in many places on the grounds. Once the walls of the tower of the astrograph were struck, but without doing any serious damage. The windows and the electric circuits suffered the most. Of course we had hidden the most valuable objectives and books of the library in safe places. During the second battle the cannonade continued without interruption day and night for six days.

"It would be interesting to know what part the American astronomers are to take in the observations of the total solar eclipses of 1922 and 1923. It is our great desire to observe these eclipses, but under the present conditions there is no hope that this wish can be fulfilled, because the difficulties in traveling to foreign countries make it practically impossible. I regret very much that since 1914 I have never been able to journey away from Pulkovo. I have had great longing for a meeting with my foreign friends, and how hard is the loss of such prominent men as Edward Pickering, Norman Lockyer, Kapteyn (sic!) H. Struve and Schwarzschild."

NOTE:—Professor J. C. Kapteyn has retired from his professorship at Groningen, having reached the age limit at that University. He is now acting as assistant director of the Leiden Observatory.

Einstein Fund and Einstein Laboratory.—"Early in 1920, following a call sent out by leading scientists, an Einstein Fund was raised. The purpose of the fund is to test the relativity theory experimentally and to make possible the development in Germany of its astrophysical consequences. Sufficient funds were obtained, thanks to the Ministry and German Industry, so that the construction of a tower-telescope and a physical laboratory could be undertaken.

"The tower-telescope is essentially like the type developed by American astronomers although there are certain rather important differences. The telescope, which is to be completed by the end of 1921, is placed within a massive tower which is surmounted by a dome. The coelostat will be of ample size, with two mirrors each 84 cm in diameter, while the lens will have a diameter of 60 cm and a focal length of 14.5 m. In a constant temperature room, 15 m. in length, will be placed two spectrographs, one furnished with a grating and the other with prisms. The dispersion of the former will be about 1 A per mm in the first order and of the latter about 2 A per mm. The grating spectrograph will be used especially for work on the sun and the prism spectrograph for the investigation of the spectra of the brighter stars with high dispersion. The telescope is located in a physical laboratory equipped in modern fashion. There is a high tension electric circuit and all other equipment required for the production of light from various sources. The establishment also contains a large room with registering photometer, a dark room, work rooms,, etc."

(Translated from the Potsdam report in the V. J. S. of the Astron. Gesell., Part 2, 1921.)

THE SHOOTING STAR.

Across the darkened dome of night
Where sun-kings reign till break of dawn,
A shooting star darts fast and bright,
Then like a spectral light is gone;
It fades from sight, and leaves behind
No more a trace than passing wind.

Yet, now and then, some shooting star
Remains much longer in the sky,
It gleams resplendent near and far,
But just the same its light must die;
Its splendor shines a little more,
Then like a breath its life is o'er.

Thus, ev'ry man, both great and small,
Whate'er his wealth or mind or fame,
Must share the common lot of all,
And leave behind a fading name;
However grand his life may be,
It soon is just a memory.

Newton, Mass., 41 Arlington St. —CHARLES NEVERS HOLMES.